Ameren MISSOURI

Callaway Plant

December 6, 2013

ULNRC-06043

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Stop P1-137
Washington, DC 20555-0001

10 CFR 50.90
10 CFR 50.59(c)(2)(viii)

Ladies and Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT
UNION ELECTRIC CO.
APPLICATION FOR AMENDMENT TO
FACILITY OPERATING LICENSE NPF-30
(LDCN 13-0016)
REVISION TO FSAR STANDARD PLANT SECTION 3.6
FOR HDPE CRACK EXCLUSION

Pursuant to 10 CFR 50.90, "Application for Amendment of License or Construction Permit," Ameren Missouri (Union Electric Company) herewith transmits an application for amendment to Facility Operating License Number NPF-30 for the Callaway Plant.

The proposed amendment would add a new pipe crack exclusion allowance to FSAR Standard Plant Section 3.6.2.1.2.4, "ASME Section III and Non-Nuclear Piping – Moderate-Energy," and FSAR Standard Plant Table 3.6-2, "Design Comparison to Regulatory Positions of Regulatory Guide 1.46, Revision 0, dated May 1973, titled 'Protection Against Pipe Whip Inside Containment,'" in particular regard to the high density polyethylene (HDPE) piping installed in ASME Class 3 line segments of the essential service water (ESW) system. The change to FSAR Standard Plant Table 3.6-2 involves Branch Technical Position (BTP) MEB 3-1 of Standard Review Plan Section 3.6.2, Revision 1, July 1981, Position B.2.c. New Reference 25 would be added to FSAR Standard Plant Section 3.6.3 to cite the NRC-approved version of the HDPE requirements covered by Relief Request I3R-10.

Ameren Missouri has determined that the proposed change requires prior NRC approval per 10 CFR 50.59(c)(2)(viii) since it involves a departure from a method of evaluation described in the updated FSAR and used in establishing the design bases or in the safety analyses.

The Enclosure to this letter provides an Evaluation of the proposed FSAR changes. Attachment 1 to the Enclosure provides the proposed FSAR Changes. Attachment 2 provides a copy of APA-ZZ-00622 Appendix F which is the controlled document containing the HDPE design requirements contained in NRC-approved Relief Request I3R-10. Attachment 3 provides a copy of the NRC Safety Evaluation for Relief Request I3R-10. Attachment 4 provides a copy of Pipe Stress Calculation 2007-16750, Revision 2, Addendum 2, which demonstrates that the applicable HDPE piping segments experience low stress conditions such that a leakage crack need not be postulated. The FSAR will be updated at the time this amendment is implemented. Attachments 2-4 are provided to facilitate the review of the FSAR changes in Attachment 1. No commitments are contained in this amendment application.

It has been determined that this amendment application does not involve a significant hazard consideration, as determined per 10 CFR 50.92, "Issuance of Amendment." In addition, pursuant to 10 CFR 51.22, "Criterion for Categorical Exclusion; Identification of Licensing and Regulatory Actions Eligible for Categorical Exclusion or Otherwise not Requiring Environmental Review," Section (b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of this amendment.

Further, this submittal does not contain any new commitments.

The Callaway Onsite Review Committee and a subcommittee of the Nuclear Safety Review Board have reviewed and approved the proposed changes, as well as the attached licensing evaluations, and have approved the submittal of this amendment application.

Ameren Missouri requests approval of this license amendment request prior to December 6, 2014. Ameren Missouri also requests that the license amendment be made effective upon NRC issuance with implementation to occur within 60 days from the date of issuance.

In accordance with 10 CFR 50.91, "Notice for Public Comment; State Consultation," Section (b)(1), a copy of this amendment application is being provided to the designated Missouri State official. If you have any questions on this amendment application, please contact me at (573) 676-8719 or Mr. Tom Elwood at (314) 225-1905.

I declare under penalty of perjury that the foregoing is true and correct.

Very truly yours,

Executed on: 12/6/2013

Scott M

Scott Maglio
Regulatory Affairs Manager

GGY/nls

Enclosure: Evaluation of the Proposed Change

Attachments to the Enclosure:

1 – FSAR Changes
2 – APA-ZZ-00662 Appendix F (Relief Request I3R-10 originally submitted for NRC review as ULNRC-05517 Enclosure 5 and revised by ULNRC-05529 Attachment 1)
3 – NRC Safety Evaluation for Relief Request I3R-10 dated 10-31-08
4 – Pipe Stress Calculation 2007-16760, Revision 2, Addendum 2

cc:

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EVALUATION OF THE PROPOSED CHANGE

EVALUATION OF THE PROPOSED CHANGE

1.0 SUMMARY DESCRIPTION

The proposed amendment would add a new pipe crack exclusion allowance to FSAR Standard Plant Section 3.6.2.1.2.4, "ASME Section III and Non-Nuclear Piping – Moderate-Energy," and FSAR Standard Plant Table 3.6-2, "Design Comparison to Regulatory Positions of Regulatory Guide 1.46, Revision 0, dated May 1973, titled 'Protection Against Pipe Whip Inside Containment.'" The change to FSAR Standard Plant Table 3.6-2 involves Branch Technical Position (BTP) MEB 3-1 of Standard Review Plan Section 3.6.2, Revision 1, July 1981, Position B.2.c. New Reference 25 would be added to FSAR Standard Plant Section 3.6.3 to cite the NRC-approved version of the HDPE requirements covered by Relief Request I3R-10. This change would add a through-wall leakage crack exception for moderate energy, low stress, high density polyethylene (HDPE) piping such that flooding from such a crack need not be evaluated for the control building basement elevation and the ultimate heat sink (UHS) cooling tower penetration rooms.

2.0 DETAILED DESCRIPTION

2.1 <u>Proposed Changes</u>

The proposed amendment would revise FSAR Standard Plant Section 3.6.2.1.2.4 to add a new crack exclusion criterion "e" by inserting the following:

> "Through-wall leakage cracks were not postulated in safety-related, Class 3, high density polyethylene (HDPE) piping provided that the maximum stress range in the piping, as calculated by the sum of the Service Level B Longitudinal Stress Equation and the Alternate Thermal Expansion or Contraction Evaluation in Reference 25, is less than 0.4 (1.2S + 1100). The Service Level B Longitudinal Stress Equation and Alternate Thermal Expansion and Contraction Evaluation in Reference 25 are equivalent to the EQN(9) and EQN(10) stresses per ASME Section III, Subarticle NC-3652, considering normal and upset conditions, respectively."

FSAR Standard Plant Table 3.6-2 (sheet 11) would be revised to clarify the existing reference to FSAR Standard Plant Section 3.6.2.1.2.4 by inserting the following:

> "Where the maximum stress range in Class 3 HDPE piping designed to Reference 25 in Section 3.6.3 is less than 0.4 (1.2S + 1100) a moderate energy crack need not be postulated. See Section 3.6.2.1.2.4."

Finally, new Reference 25 would be added to FSAR Standard Plant Section 3.6.3, as follows:

> "25. APA-ZZ-00662, Appendix F, "Requirements for High Density Polyethylene (HDPE) Piping for Nuclear Service," Relief Request I3R-10, originally submitted for NRC review as ULNRC-05517 Enclosure 5 and revised by ULNRC-05529 Attachment 1, approved by NRC letter October 31, 2008."

The FSAR markups are provided in Attachment 1.

2.2 Background

System Description

The ESW system provides a heat sink for the removal of process and operating heat from safety-related components during a design basis accident (DBA) or transient. During normal operation, and a normal shutdown, the ESW system also provides this function for various safety-related and non-safety related components and receives coolant flow from the non-safety related service water system.

The ESW system consists of two separate, 100% capacity, safety-related, cooling water trains. Each train consists of a self-cleaning strainer, prelube tank, one 100% capacity pump, piping, valving, and instrumentation. The pumps and valves are remotely and manually aligned, except in the unlikely event of a loss of coolant accident (LOCA). The pumps are automatically started upon receipt of a safety injection signal, low suction pressure to the auxiliary feedwater pumps coincident with an auxiliary feedwater actuation signal (AFAS), or loss of offsite power. Upon receipt of one of these signals, the automatically actuated essential valves are aligned to their post-accident positions as required. The ESW system also provides emergency makeup to the spent fuel pool and CCW system and is the backup water supply to the auxiliary feedwater system.

Additional information about the design and operation of the ESW system, along with a list of the components served, is presented in the FSAR Standard Plant Section 9.2.1.2. The principal safety-related function of the ESW system is the removal of decay heat from the reactor via the CCW system and removal of containment heat loads via the containment coolers.

The UHS provides a heat sink during a transient or accident, as well as during normal operation, via the essential service water (ESW) system. The two principal functions of the UHS are the dissipation of residual heat after reactor shutdown and dissipation of residual heat after an accident.

The UHS consists of a 4-cell seismic Category I mechanical draft cooling tower and a seismic Category I source of makeup water (retention pond) for the cooling tower. Heat from the ESW system is rejected to the UHS to permit a safe shutdown of the plant following an accident. The UHS enables the ESW system to remove the various component heat loads. The mechanical draft cooling tower is a safety-related, seismic Category I structure sized with 100-percent redundancy to provide heat dissipation for safe shutdown following an accident.

ESW return flow from the power block is directed to the UHS cooling tower basin through normally open UHS cooling tower bypass valves (EFHV0065 in 'A' train, EFHV0066 in 'B' train). The position of the bypass valve in each train is normally controlled by ESW return water (UHS cooling tower inlet) temperature. This design provides freeze protection for the UHS cooling tower fill. ESW return flow from power block loads is normally directed through the open UHS cooling tower bypass valves to the cooling tower basin, thus bypassing the cooling tower fill. If the ESW return flow temperatures increase sufficiently, the UHS cooling tower bypass valves will automatically close.

<u>Need for License Amendment</u>

NRC approved ASME Code Relief Request I3R-10 (References 6.1 and 6.2) allowing Callaway Plant to replace some of the Class 3 metallic ESW piping with high density polyethylene (HDPE) piping. The associated plant modification package (MP 07-0066) installed the HDPE piping in 36-inch diameter pipelines designated in the plant as EF-003-AZC-36", EF-007-AZC-36", EF-083-AZC-36", and EF-140-AZC-36". These pipelines are the supply and return headers for the ESW system as shown on FSAR Site Addendum Figure 3.8-4 sheet 2. The supply headers (EF-003-AZC-36" and EF-007-AZC-36") carry water from the ESW pumphouse to the control building basement. The HDPE portion extends underground from the ESW supply line yard vaults (which are train-separated) to the control building basement where, after penetrating the below-grade basement wall, it transitions to stainless steel piping via transition flanges within 3' - 9.25" of the centerline of the basement wall. The return headers (EF-083-AZC-36" and EF-140-AZC-36") are also HDPE and carry water from within 3' - 9.25" of the centerline of the below-grade control building basement wall to the below-grade portions of the penetration rooms (which are train-separated) of the UHS cooling tower.

The evaluations performed in support of MP 07-0066 failed to include an internal flooding analysis for the HDPE piping that was installed in the basement of the control building (room 3101), the UHS cooling tower penetration rooms, and the ESW supply line yard vaults.

No licensing basis, regulatory guidance, or industry guidance exists for postulating moderate energy cracks in non-metallic piping. The proposed FSAR change adds another crack exclusion criterion to FSAR Standard Plant Section 3.6.2.1.2.4 with a similar change made to FSAR Standard Plant Table 3.6-2.

A new method of evaluation is proposed to be added to the section of the updated FSAR that establishes the design bases for internal flooding. Ameren Missouri is proposing an addition to the scope of the crack exclusion exceptions listed in FSAR Standard Plant Section 3.6.2.1.2.4 to add a low stress exclusion criterion for HDPE designed to NRC-approved Relief Request I3R-10 (APA-ZZ-00662 Appendix F) as described in References 6.1 and 6.2. (See Attachments 2 and 3 to this Evaluation.) This proposed FSAR change eliminates the need to postulate a moderate energy pipe crack in the above-ground HDPE piping installed by MP 07-0066.

Ameren Missouri has performed an analysis that shows that the HDPE piping within the control building and the UHS cooling tower penetration rooms has stresses that are sufficiently low enough that the probability of a crack developing is reasonably low. Therefore, no crack need be postulated. The consequences of a pipe crack in the ESW supply line yard vaults have been reviewed and will not adversely affect any other safety-related equipment, including the opposite ESW train.

3.0 TECHNICAL EVALUATION

A moderate energy pipe failure is defined in NRC Branch Technical Positions (BTP) ASB 3-1 and MEB 3-1 which are discussed in FSAR Standard Plant Table 3.6-2. Unless the piping meets one of the existing exceptions listed in FSAR Standard Plant Section 3.6.2.1.2.4, the moderate energy pipe failure for safety-related Class 3 piping is defined as a crack with an area (per BTP MEB 3-1 Position B.3.c.(2) in FSAR Standard Plant Table 3.6-2 sheet 14 and FSAR Standard Plant Section 3.6.2.1.3.2) characterized as a circular opening with a cross-sectional flow area equal to that of a rectangle one-half the pipe inside diameter in length and one-half the pipe wall thickness in width.

FSAR Standard Plant Section 3.6.2.1.2.4 item "c" contains a crack exception for piping designed to ASME Section III, Class 2 or 3, and non-nuclear seismic Category 1 class piping. Meeting this exception requires the maximum stress range in the piping, as calculated by the sum of Equation 9 and Equation 10 in Subarticle NC-3652 of the ASME Code Section III, considering normal and upset plant conditions, to be less than $0.4\ (1.2S_h + S_A)$, where S_h is the allowable stress at the maximum (hot) temperature and S_A is the allowable stress for thermal expansion. If this stress criterion is met, then a moderate energy pipe crack is not required to be postulated.

The HDPE piping installed under MP 07-0066 was not designed to Subarticle NC-3652 of ASME Section III. The specifics of the HDPE design were submitted to the NRC for review (via Enclosure 5 to letter ULNRC-05517 dated 7-10-08, as revised by Attachment 1 to letter ULNRC-05529 dated 7-24-08) and approved via Relief Request I3R-10 (Reference 6.2; a copy is provided as Attachment 3 to this Enclosure). The HDPE piping design requirements contained in NRC-approved Relief Request I3R-10 have been captured in APA-ZZ-00662 Appendix F (Attachment 2 to this Enclosure).

Since the HDPE piping was not designed to Subarticle NC-3652 of ASME Section III, the exception in FSAR Section 3.6.2.1.2.4 item "c" does not strictly apply.

The proposed FSAR change would add an additional exception specifically for low stress HDPE piping designed to Attachment 2, which would include the 36-inch ESW supply and return lines EF-003-AZC-36", EF-007-AZC-36", EF-083-AZC-36", and EF-140-AZC-36" (i.e., the applicable HDPE piping segments in the control building basement and UHS penetration rooms) . The design criteria in Attachment 2 are different than those of ASME Section III; however, the stresses calculated can be combined to represent Equations 9 and 10 of ASME Section III NC-3652 as illustrated in Pipe Stress Calculation 2007-16760 Revision 2 Addendum 2 (Attachment 4 to this Enclosure). That calculation supports a determination that cracks need not be postulated in this HDPE piping for the purpose of evaluating flooding impacts, based on the demonstration in that calculation that the maximum stress range in the Class 3 HDPE piping is less than 0.4 (1.2S + 1100) .

4.0 REGULATORY SAFETY ANALYSIS

4.1 Applicable Regulatory Requirements / Criteria

10 CFR 50.59 establishes the conditions under which licensees may make changes to the facility or procedures and conduct tests or experiments without prior NRC approval. Proposed changes, tests and experiments that satisfy the definitions and one or more of the criteria in the rule must be reviewed and approved by the NRC before licensee implementation.

The evaluation methods described in the updated FSAR include methods used in supporting FSAR analyses that demonstrate that intended design functions will be accomplished under design basis natural phenomena, environmental conditions, dynamic effects, station blackout, and other events that the plant is required to withstand. The NRC's Branch Technical Positions (including MEB 3-1 as well as Regulatory Guide 1.46 Revision 0 which was withdrawn after Callaway's full power license was issued) are methods used to support FSAR analyses that demonstrate that intended design functions will be accomplished, i.e., that safe shutdown can be achieved with consideration given to the dynamic effects of a moderate energy pipe break.

Changes to evaluation methods described in the FSAR are considered to be adverse and require evaluation under 10CFR50.59 if the changes are outside the constraints and limitations associated with use of the method. In addition, the proposed use of an alternative method is considered an adverse change that must be evaluated under 10CFR50.59. The proposed change, which involves applying an alternate method to add a low stress, leakage crack exception for HDPE piping, represents a change in method for postulating moderate energy leakage cracks.

The proposed change, therefore, requires the submittal of a license amendment pursuant to 10 CFR 50.90 as required by 10CFR50.59(c)(2)(viii).

The following regulatory requirements and guidance documents also apply to the ESW system:

GDC 2 requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without the loss of the capability to perform their safety functions.

GDC 4 requires that structures, systems, and components important to safety be designed to accommodate the effects of, and to be compatible with, the environmental conditions associated with the normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, discharging fluids that may result from equipment failures, and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.

GDC 44 - Cooling Water

"A system to transfer heat from structures, systems, and components important to safety, to an ultimate heat sink shall be provided. The system safety function shall be to transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions. Suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure."

GDC 45 - Inspection Of Cooling Water System

"The cooling water system shall be designed to permit appropriate periodic inspection of important components, such as heat exchangers and piping, to assure the integrity and capability of the system."

GDC 46 - Testing Of Cooling Water System

"The cooling water system shall be designed to permit appropriate periodic pressure and functional testing to assure (1) the structural and leaktight integrity of its components, (2) the operability and the performance of the active components of the system, and (3) the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation for reactor shutdown and for loss-of-coolant accidents, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources."

Regulatory Guide 1.27 describes requirements to be met by the Ultimate Heat Sink. This Regulatory Guide requires Callaway Plant to have a reliable source of cooling water that can assure the safe shutdown of the plant during a Design Basis Accident over a 30-day time frame.

There are no changes proposed in this license amendment application that would be in conflict with any of the above regulatory requirements.

4.2 <u>No Significant Hazards Consideration (NSHC) Determination</u>

This section addresses the standards of 10 CFR 50.92 as well as the applicable regulatory requirements and acceptance criteria.

The proposed amendment would add a new pipe crack exclusion allowance to FSAR Standard Plant Section 3.6.2.1.2.4, "ASME Section III and Non-Nuclear Piping – Moderate-Energy," and FSAR Standard Plant Table 3.6-2, "Design Comparison to Regulatory Positions of Regulatory Guide 1.46, Revision 0, dated May 1973, titled 'Protection Against Pipe Whip Inside Containment.'" The change to FSAR Standard Plant Table 3.6-2 involves Branch Technical Position (BTP) MEB 3-1 of Standard Review Plan Section 3.6.2, Revision 1, July 1981, Position B.2.c. New Reference 25 would be added to FSAR Standard Plant Section 3.6.3 to cite the NRC-approved version of the HDPE requirements covered by Relief Request I3R-10. This change would add a through-wall leakage crack exception for moderate energy, low stress, high density polyethylene (HDPE) piping such that flooding from such a crack need not be evaluated for the control building basement elevation and the ultimate heat sink (UHS) cooling tower penetration rooms.

Ameren Missouri has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," Part 50.92(c), as discussed below:

1. Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No

There are no new design changes associated with the proposed amendment. All design, material, and construction standards that were applicable prior to this amendment request, including those standards in place following the NRC approval of using the HDPE piping, will continue to be applicable.

The proposed change will not increase the likelihood of accident initiators or precursors or adversely alter the design assumptions, conditions, and configuration of the facility or the manner in which the plant is operated and maintained with respect to such initiators or precursors.

The proposed changes do not affect the way in which safety-related systems perform their functions.

All accident analysis acceptance criteria will continue to be met with the proposed changes. The proposed changes will not affect the source term, containment isolation, or radiological release assumptions used in evaluating the radiological consequences of an accident previously evaluated. The proposed changes will not alter any assumptions or change any mitigation actions in the radiological consequence evaluations in the FSAR.

The applicable radiological dose acceptance criteria will continue to be met.

Since the proposed change is based on a calculation that demonstrates that a moderate energy crack in the ESW HDPE piping is unlikely, there are no impacts on the plant's existing hazard analyses.
The proposed change does not physically alter safety-related systems or affect the way in which safety-related systems perform their functions per the intended plant design.

As such, the proposed change will not alter or prevent the capability of structures, systems, and components (SSCs) to perform their intended functions for mitigating the consequences of an accident and meeting applicable acceptance limits.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No

With respect to any new or different kind of accident, there are no new design changes being proposed nor are there any changes in the method by which any safety-related plant SSC performs its specified safety function. The proposed change will not affect the normal method of plant operation. No new transient precursors will be introduced as a result of this amendment.

The HDPE piping design change was previously approved by the NRC under Relief Request I3R-10. The proposed change in this amendment request does not create the possibility of a new type of accident, rather the proposed change seeks to eliminate the need to postulate an existing type of hazard event (moderate energy piping leakage crack) for the subject HDPE piping which has been shown to experience such low stresses that such a crack, and the potential flooding for that hazard event, need not be postulated.

The change does not have a detrimental impact on the manner in which plant equipment operates or responds to an actuation signal.

The proposed change does not, therefore, create the possibility of a new or different accident from any accident previously evaluated.

3. Does the proposed change involve a significant reduction in a margin of safety?

Response: No

There will be no effect on those plant systems necessary to assure the accomplishment of protection functions associated with reactor operation or the reactor coolant system. The design factor (DF) of 0.50 discussed in ULNRC-05553 dated October 9, 2008 has not changed. This DF was approved by the NRC in Relief Request I3R-10 (Reference 6.2 to this Evaluation). There will be no impact on the overpower limit, departure from nucleate boiling ratio (DNBR) limits, heat flux hot channel factor (F_Q), nuclear enthalpy rise hot channel factor ($F\Delta H$), loss of coolant accident peak cladding temperature (LOCA PCT), peak local power density, or any other limit and associated margin of safety. Required shutdown margins in the COLR will not be changed.

The proposed change does not eliminate any surveillances or alter the frequency of surveillances required by the Technical Specifications.

As such, the proposed change does not involve a significant reduction in a margin of safety as defined in any regulatory requirement or guidance document.

Based on the above evaluation, Ameren Missouri concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c) and, accordingly, a finding of "no significant hazards consideration" is justified.

4.3 Conclusions

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the

Commission's regulations, and (3) issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

Ameren Missouri has evaluated the proposed amendment and has determined that the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

6.1 APA-ZZ-00662, Appendix F, "Requirements for High Density Polyethylene (HDPE) Piping for Nuclear Service," Relief Request 13R-10, originally submitted for NRC review as ULNRC-05517 Enclosure 5 and revised by ULNRC-05529 Attachment 1.

6.2 Letter from Michael T. Markley (NRC) to Adam C. Heflin (Union Electric Company) dated October 31, 2008, Callaway Plant, Unit 1 – Relief Request I3R-10 for Third 10-Year Inservice Inpsection Interval, Use of Polyethylene Pipe in lieu of Carbon Steel Pipe in Buried Essential Service Water Piping System (TAC No. MD6792).

ATTACHMENT 1

FSAR MARKUPS

INSERT 1

Through-wall leakage cracks were not postulated in safety-related, Class 3, high density polyethylene (HDPE) piping provided that the maximum stress range in the piping, as calculated by the sum of the Service Level B Longitudinal Stress Equation and the Alternate Thermal Expansion or Contraction Evaluation in Reference 25, is less than 0.4 (1.2S + 1100). The Service Level B Longitudinal Stress Equation and Alternate Thermal Expansion and Contraction Evaluation in Reference 25 are equivalent to the EQN(9) and EQN(10) stresses per ASME Section III, Subarticle NC-3652, considering normal and upset conditions, respectively.

INSERT 2

Where the maximum stress range in Class 3 high density polyethylene (HDPE) piping designed to Reference 25 in Section 3.6.3 is less than 0.4 (1.2S + 1100) a moderate energy crack need not be postulated. See Section 3.6.2.1.2.4.

INSERT 3

25. APA-ZZ-00662, Appendix F, "Requirements for High Density Polyethylene (HDPE) Piping for Nuclear Service," Relief Request 13R-10, originally submitted for NRC review as ULNRC-05517 Enclosure 5, revised by ULNRC-05529 Attachment 1, and approved by NRC October 31, 2008.

b. Longitudinal breaks in piping 4 inches and larger, except at terminal ends.

3.6.2.1.2.4 ASME Section III and Non-Nuclear Piping - Moderate - Energy

Through-wall leakage cracks were postulated in moderate-energy piping larger than 1 inch located within, or outside and adjacent to, protective structures, except as noted in the following:

a. Through-wall leakage cracks were not postulated in those portions of piping between containment isolation valves, since this piping meets the requirements of ASME Code, Section III, Subarticle NE-1120 and is designed so that the maximum stress range does not exceed 0.4 ($1.2\ S_h + S_A$).

b. Through-wall leakage cracks were not postulated in moderate-energy fluid system piping located in the same area in which a break in high-energy fluid system piping was postulated, provided that such cracks would not result in more limiting environmental conditions than the high-energy pipe break.

c. Through-wall leakage cracks were not postulated in ASME Code, Section III, Class 2 or 3 piping and stress analyzed non-nuclear seismic Category I class piping, provided that the maximum stress range in the piping, as calculated by the sum of EQN(9) and EQN(10) in Subarticle NC-3652 of the ASME Code, Section III, considering normal and upset plant conditions, is less than 0.4 ($1.2\ S_h + S_A$).

d. Cracks were not postulated when a review of the piping layout and plant arrangement drawings showed that the effects of through-wall leakage cracks at any location in the piping designed to seismic or nonseismic standards were isolated or physically remote from structures, systems, and components required for safe shutdown.

e. INSERT /

Cracks were postulated to occur individually at locations that resulted in the maximum effects from fluid spraying and flooding, with the consequent hazards or environmental conditions. Flooding effects were determined on the basis of a conservatively estimated time period required to effect corrective actions. Further discussion of flooding effects is provided in Appendix 3B.

3.6.2.1.3 Break/Crack Configuration

3.6.2.1.3.1 High-Energy Break Configuration

The ends of a circumferentially ruptured pipe were assumed to be displaced laterally by a distance equal to or greater than one pipe diameter until and unless one end was restrained in the lateral direction.

 No changes

Movement was assumed to be in the direction of the jet reaction initially, and total path controlled by the piping geometry.

The orientation of a longitudinal break, except when otherwise justified by a detailed stress analysis, was considered to cause piping movement normal to the plane of the piping system. The flow area of such a break was equal to the cross-sectional flow area of the pipe. Longitudinal breaks were assumed to be oriented (but not concurrently) at two diametrically opposed points on the piping circumference. Longitudinal and circumferential breaks were not postulated concurrently.

3.6.2.1.3.2 Moderate-Energy Crack Configuration

Moderate-energy crack openings were assumed to be a circular orifice of cross-sectional flow area equal to that of a rectangle one-half the pipe inside diameter in length and one-half pipe wall thickness in width.

3.6.2.2 Analytical Methods to Define Forcing Functions and Response Models

3.6.2.2.1 Forcing Functions for Pipe Whip and Jet Impingement

To determine the forcing function, the fluid conditions at the upstream source and at the break exit will dictate the analytical approach and approximations that are used. For most applications, one of the following situations will exist:

a. Superheated or saturated steam

b. Saturated or subcooled water

c. Cold water (non-flashing)

The following three sections describe simplified models that take into account the fluid conditions. Where more complex analysis is warranted, such as for the main steam line, a RELAP4 analysis can be performed, as described in Section 3.6.2.2.1.4. For a discussion of the jet thrust forcing functions from reactor coolant loop breaks, see Section 3.6.2.2.1.5.

3.6.2.2.1.1 Superheated or Saturated Steam Break Analysis

For superheated or saturated steam, steady state thrust forces are calculated from the ideal gas relationship. This relationship has been calculated using Fanno lines, assuming homogeneous flow for superheated steam, in Reference 5, Figure 2-1. When the fluid expands into the wet region, it is treated as having a specific heat ratio of 1.1. Whether the specific heat ratio is 1.1 or 1.3, the values of Figure 2-1 of Reference 5 are used.

No change - see page 3.6-36

c. The methods and analysis procedures used to determine jet impingement loads associated with the rupture of the reactor coolant loop piping are discussed in Section 3.6.2.3. These loads are used to determine the adequacy of the primary equipment and supports.

d. Design loading combinations and applicable criteria for ASME Class 1 components and supports are provided in Section 3.9(N).1.4. Pipe rupture loads include not only the jet thrust forces acting on the piping but also jet impingement loads on the primary equipment and supports.

3.6.3 REFERENCES

1. "Pipe Breaks for the LOCA Analysis of the Westinghouse Primary Coolant Loop," WCAP-8082-P-A (Proprietary) and WCAP-8172-A (Non-Proprietary), January 1975.

2. Takeuchi, K., et al., "MULTIFLEX-A FORTRAN-IV Computer Program for Analyzing Thermal-Hydraulic-Structure System Dynamics," WCAP-8708-P-A, Volumes 1 and 2 (Proprietary) and WCAP-8709-A, Volumes 1 and 2 (Non-Proprietary), February 1976.

3. Bordelon, F. M., "A Comprehensive Space-Time Dependent Analysis of Loss-of-Coolant (SATAN-IV Digital Code)," WCAP-7750, August 1971.

4. "Documentation of Selected Westinghouse Structural Analysis Computer Codes," WCAP-8252, Revision 1, May 1977.

5. "Design for Pipe Break Effects," BN-TOP-2, Revision 2, Bechtel Power Corporation, May 1974.

6. NRC Branch Technical Position ASB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," November 24, 1975.

7. NRC Branch Technical Position MEB 3-1, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," November 24, 1975.

8. Moody, F. J., "Fluid Reaction and Impingement Loads," presented at the ASCE Specialty Conference, Chicago, Ill., December 1973.

9. American Society of Mechanical Engineers, "Thermodynamic and Transport Properties of Steam Comprising Tables and Charts for Steam and Water," 1967 Edition.

10. Aerojet Nuclear Company, "RELAP4/MOD5 - A Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems," Volumes I-III, ANCR-NUREG-1335, September 1976.

No change - see page 3.6-36

11. Moody, F. J., "Time-Dependent Pipe Forces Caused by Blowdown and Flow Stoppage," ASME Paper No. 73-FE-23, June 1973.

12. "Subcompartment Pressure Analyses," BN-TOP-4, Revision 1, Bechtel Power Corporation, October 1977.

13. Gerber, T. L., "Plastic Deformation of Piping Due to Pipe-Whip Loading," ASME Paper No. 74-NE-1, June 1974.

14. Biggs, J. M., Introduction to Structural Dyanmics, McGraw-Hill Book Company, New York, 1964.

15. NRC Branch Technical Position MEB 3-1, "Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment," June 1987.

16. "Structural Evaluation of the Wolf Creek and Callaway Pressurizer Surge Lines, Considering the Effects of Thermal Stratification," WCAP-12893, Rev. 0, March 1991.

17. "Structural Analysis of the Reactor Coolant Loop for Standard Nuclear Unit Power Plant System," WCAP-9728 Volume 1 Revision 4, July 2004.

18. WCAP-10691, “Technical Basis for Eliminating Large Primary Loop Pipe Rupture as a Structural Design Basis for Callaway and Wolf Creek Plants,” October, 1984.

19. “Technical Justification for Eliminating 10-inch Accumulator Lines Rupture as the Structural Design Basis for Callaway Nuclear Power Plant,” WCAP-16019-P (Proprietary) and WCAP-16019-NP (Non-Proprietary), February 2003.

20. “Technical Justification for Eliminating 12-inch Residual Heat Removal (RHR) Lines Rupture as the Structural Design Basis for Callaway Nuclear Power Plant,” WCAP-16020-P (Proprietary) and WCAP-16020-NP (Non-Proprietary), February 2003.

21. Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Amendment No. 161 to Facility Operating License No. NPF-30 Union Electric Company Callaway Plant, Unit 1 Docket No. 50-483, dated April 12, 2004.

22. WCAP-14059, “Technical Justification for Eliminating Large Primary Loop Pipe Rupture as the Structural Design Basis for the Callaway and Wolf Creek Plants after Elimination of SG Snubbers,” August 1994 (Westinghouse Proprietary Class 2).

23. Modification of General Design Criterion 4 Requirements for Protection Against Dynamic Effects of Postulated Pipe Ruptures -- Final Rule (Broad Scope), 52 FR 41288, October 27, 1987.

24. NRC Generic Letter 87-11, "Relaxation in Arbitrary Intermediate Pipe Rupture Requirements," June 19, 1987.

25. INSERT 3

TABLE 3.6-2 DESIGN COMPARISON TO REGULATORY POSITIONS OF REGULATORY GUIDE 1.46, REVISION 0, DATED MAY 1973, TITLED "PROTECTION OF PIPE WHIP INSIDE CONTAINMENT"

The basis for compliance to Regulatory Guide 1.46 is the implementation of NRC Branch Technical Position (BTP) MEB 3-1, NRC BTP ASB 3-1, WCAP-8082-P-A, and WCAP-8172-A. The following provides a summary of the compliance with MEB 3-1 and ASB 3-1.

BTP ASB 3-1 Position	Union Electric Compliance
B.1 Plant Arrangement	
Protection of essential systems and components against postulated piping failures in high- or moderate-energy fluid systems that operate during normal plant conditions and that are located outside of containment should be provided by one of the following plant arrangement considerations:	B.1. Complies. See Section 3.6.1.3.
B.1.a. Plant arrangements should separate fluid system piping from essential systems and components. Separation should be distances between essential systems and components and fluid system piping such that the effects of any postulated piping failure therein (e.g., pipe whip, jet impingement, and the environmental conditions resulting from the escape of contained fluids as appropriate to high- or moderate-energy fluid system piping) cannot impair the integrity or operability of essential systems and components.	
B.1.b. Fluid system piping or portions thereof not satisfying the provisions of B.1.a should be enclosed within structures or compartments designed to protect nearby essential systems and components. Alternatively, essential systems and components may be enclosed within structures or compartments designed to withstand the effects of postulated piping failures in nearby fluid systems.	
B.1.c. Plant arrangements or system features that do not satisfy the provisions of either B.1.a or B.1.b should be limited to those for which the above provisions are impractical because of the stage of design or construction of the plant; because the plant design is based upon that of an earlier plant accepted by the staff as a base plant under the Commission's standardization and replication policy; or for other substantive reasons such as particular design features of the fluid systems. Such cases may arise, for example, (1) at interconnections between fluid systems and essential systems and components, or (2) in fluid systems having dual functions (i.e., required to operate during normal plant conditions as well as to shut down the reactor). In these cases, redundant design features that are separated or otherwise protected from postulated piping failures, or additional protection, should be provided so that the effects of postulated piping failures are shown by the analyses and guidelines of B.3 to be acceptable. Additional protection may be provided by restraints and barriers or by designing or testing essential systems and components to withstand the effects associated with postulated piping failures.	

No change - see sheet 11

TABLE 3.6-2 (Sheet 11)

BTP MEB 3-1 Position	Union Electric Compliance
(3) Applicable to (1) and (2) above: If a structure separates a high energy line from an essential component, that separating structure should be designed to withstand the consequences of the pipe break in the high-energy line which produces the greatest effect at the structure irrespective of the fact that the above criteria might not require such a break location to be postulated.	B.1.d.(3) Complies.
B.1.e. The designer should identify each piping run he has considered to postulate the break locations required by B.1.c and B.1.d above. In complex systems such as those containing arrangements of headers and parallel piping running between headers, the designer should identify and include all such piping within a designated run in order to postulate the number of breaks required by these criteria.	B.1.e. Complies. See Section 3.6.2.5.
B.2. Moderate-Energy Fluid System Piping	
B.2.a. Fluid Systems Separated from Essential Systems and Components For the purpose of satisfying the separation provisions of plant arrangement as specified in B.1.a of BTP ASB 3-1, a review of the piping layout and plant arrangement drawings should clearly show that the effects of through-wall leakage cracks at any location in piping designed to seismic and non-seismic standards are isolated or physically remote from essential systems and components.	B.2.a. Complies. See Section 3.6.1.3 and Appendix 3B.
B.2.b. Fluid System Piping Between Containment Isolation Valves Leakage cracks need not be postulated in those portions of piping identified in B.2.c. of (BTP) ASB 3-1 provided they meet the requirements of the ASME Code, Section III, Subarticle NE-1120, and are designed such that the maximum stress range does not exceed 0.4 $(1.2S_h + S_A)$ for ASME Code, Section III, Class 2 piping.	B.2.b. Complies. See Section 3.6.2.1.2.4.
B.2.c. Fluid Systems Within, or Outside and Adjacent to, Protective Structures i. Through-wall leakage cracks should be postulated in seismic Category I fluid system piping located within, or outside and adjacent to, protective structures designed to satisfy the plant arrangement provisions of B.1.b. or B.1.c of BTP ASB 3-1, except (1) where exempted by B.2.b and B.2.d, or (2) where the maximum stress range in these portions of Class 2 or 3 piping (ASME Code, Section III), or non-nuclear piping is less than $0.4(1.2S_h + S_A)$. The cracks should be postulated to occur individually at locations that result in the maximum effects from fluid spraying and flooding, with the consequent hazards or environmental conditions developed. ii. Through-wall leakage cracks should be postulated in fluid system piping designed to non-seismic standards as necessary to satisfy B.3.d of BTP ASB 3-1.	B.2.c. ~~See compliance statement to B.2.b above.~~ INSERT 2

TABLE 3.6-2 (Sheet 14)

BTP MEB 3-1 Position	Union Electric Compliance
(4) The dynamic force of the fluid jet discharge should be based on circular or elliptical (2D x 1/2D) break area equal to the effective cross-sectional flow area of the pipe at the break location and on a calculated fluid pressure modified by an analytically or experimentally determined thrust coefficient as determined for a circumferential break at the same location. Line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs may be taken into account, as applicable, in the reduction of jet discharge.	B.3.b.(4) See Section 3.6.2.2.1
(5) Piping movement should be assumed to occur in the direction of the jet reaction unless limited by structural members, piping restraints, or piping stiffness as demonstrated by inelastic limit analysis.	B.3.b.(5) Complies.
B.3.c. Through-Wall Leakage Cracks The following through-wall leakage cracks should be postulated in moderate-energy fluid system piping at the locations specified in B.2 of this position:	
(1) Cracks should be postulated in moderate-energy fluid system piping and branch runs exceeding a nominal pipe size of 1 inch.	B.3.c.(1) Complies.
(2) Fluid flow from a crack should be based on a circular opening of area equal to that of a rectangle one-half pipe-diameter in length and one half pipe wall thickness in width.	B.3.c.(2) Complies.
(3) The flow from the crack should be assumed to result in an environment that wets all unprotected components within the compartment, with the consequent flooding in the compartment and communicating compartments. Flooding effects should be determined on the basis of a conservatively estimated time period required to effect corrective actions.	B.3.c.(3) Complies.

No Change

ATTACHMENT 2

APA-ZZ-00662 APPENDIX F

(Relief Request I3R-10 submitted by ULNRC-05517 Enclosure 5
and revised by ULNRC-05529 Attachment 1)

AmerenUE
Callaway Plant

APA-ZZ-00662 APPENDIX F

REQUIREMENTS FOR HIGH DENSITY POLYETHYLENE (HDPE) PIPING FOR NUCLEAR SERVICE

MINOR Revision 005

INFORMATION USE

PROCEDURE REVIEW FORM

1.0 Initiation

Initiator: Matt Brandes | Date: 20090422 | Initiator Dept: NEMM | Ext.: 68953

Document: APA-ZZ-00662 Appendix F | Rev. # 005 | Responsible Dept: NEP

Title: Requirements for High Density Polyethylene (HDPE) Piping for Nuclear Service

Is this a Temporary Procedure? ☐Yes
If yes, Expiration Date: ______

Level of Use: ☐Continuous ☐Reference ☒Information ☐Multiple ☐N/A

2.0 Reason for Change *(List commitments, CARS, eB Change Requests, OERs, Plant Mods etc. and record numbers here.)*

CAR 200902327

Continued: ☐

3.0 Description of Change

Section -3010 Nomenclature: for ring deflection, added unit of measure clarification. Section -3030 Soil and Surcharge Loads: added Caution regarding use of proper units when comparing ring deflection expressed as a ratio to maximum ring deflection expressed as a percentage.

Continued: ☐

4.0. Document Disposition

☐Temp Change ☐New Document ☐Major Revision ☒Minor Revision ☐Cancellation

☐Administrative Correction N/A

Designated Approval Authority (Print/Sign/Date)
Administrative Correction Approval Only

5.0 Interim Approval *(Temporary Change Only)* Temp Change #: ______

N/A — Cognizant Supervisor (Print/Sign/Date)
N/A — SRO (Print/Sign/Date)

6.0 Comments:

Continued: ☐

7.0 Reviews and Signatures

Reviews Required	*Dept*	*Print Name*	*Sign*	*Date*	*CA0139 Attached*
Preparer	NEXC	James Klusman	James Klusman	04/22/09	N/A
Technical Review	NEMM	Matt Brandes	Matt Brandes 12276	06/24/09	☐ Yes ☒ No
Technical Review	NEDX	Randall Wilson	Randall Wilson 15254	06/24/09	☐ Yes ☒ No
☐Additional Review					☐ Yes ☐ No
☒Additional Review	NEXC	Linda Robbins	Linda Robbins	4-22-09	☐ Yes ☒ No

☐Additional Reviews *(See Attached CA0139 forms)*. Number of additional CA0139s: ____

☐Validation	*Type*	*Coordinator - Print Name*	*Sign*	*Date*	*CA0139 Attached*
					☐ Yes ☐ No

50.59 Review ☐CA2510 ☐CA2511 ☐CA2512 ☒N/A *(per APA-ZZ-00143)* per 10CFR50.59 RM section 4.2.6 — Matt Brandes/12276 (Screener / PIN) — RWW 15254 6/24/09 (Reviewer / PIN)

(Dept. Head or Designated Approver) Is a Change Management Plan required? ☐Yes ☑No

8.0 Approval

☐Recommend for Plant Director Approval *(APA & EIP Main Body, Addenda, and revision '0' Appendices required.)*

☑Department Head Final Review and Approval

ORC Meeting: ______

ROGER D. MYATT 4145 Roger D. Myatt 7/16/09
Dept. Head or Designated Approver (Print/Sign/Date)

Plant Director (Print/Sign/Date)

9.0 Issue ☐Immediate ☐Other, Specify: ______ Actual Issue Date: 7/20/09

RECEIVED JUL 2009

Note: Page 2 provides instructions to complete this form and may be discarded

Brandes, Matthew D

From: Thadani, Mohan [Mohan.Thadani@nrc.gov]
Sent: Wednesday, June 17, 2009 10:25 AM
To: Elwood, Thomas B
Cc: Basavaraju, Chakrapani; Maglio, Scott A
Subject: RE: Reminder re Issue Concerning Change to Callaway's Design Requirements Procedure for HDPE Piping

I agree.

From: Elwood, Thomas B [mailto:TElwood@ameren.com]
Sent: Tuesday, June 16, 2009 5:35 PM
To: Thadani, Mohan
Cc: Basavaraju, Chakrapani; Maglio, Scott A
Subject: RE: Reminder re Issue Concerning Change to Callaway's Design Requirements Procedure for HDPE Piping

Thank you very much, Mohan (and Pani). As I see it, Pani is fine with the clarification and no letter or further interaction (between you and us) is needed. Do you agree, Mohan?

- Tom Elwood

From: Basavaraju, Chakrapani [mailto:Chakrapani.Basavaraju@nrc.gov]
Sent: Tuesday, June 16, 2009 3:51 PM
To: Thadani, Mohan
Cc: Khanna, Meena
Subject: RE: Reminder re Issue Concerning Change to Callaway's Design Requirements Procedure for HDPE Piping

Mohan,

I reviewed the revised pages (8 & 9 of 64) of the document, Design Requirements Procedure, APA-ZZ-00662 Rev.4, Appendix F, clarifying that Omega is a ratio of ring deflection to diameter, and adding a caution about the use of proper units. This is in accordance with my Callaway EMCB Round 2 RAI question 11(c). The clarifications provided by AmerenUE as revision to the document APA-ZZ-00662 are acceptable.

Thanks

Pani

Chakrapani Basavaraju
Mechanical Engineer
NRR/ADES/DE/EMCB

301-415-1221

From: Thadani, Mohan
Sent: Tuesday, June 16, 2009 11:36 AM
To: Basavaraju, Chakrapani
Subject: FW: Reminder re Issue Concerning Change to Callaway's Design Requirements Procedure for HDPE Piping

Pani:

I have received the following email from Callaway regarding the HDPE piping design requirements procedure. Please see the email below and let me know if a phone call with the licensee is needed as suggested in the email below. I have a weekly phone call with the licensee tomorrow at 9:30. Let me know before that.

Thanks.

Mohan

From: Elwood, Thomas B [mailto:TElwood@ameren.com]
Sent: Monday, June 15, 2009 7:56 PM
To: Thadani, Mohan
Subject: Reminder re Issue Concerning Change to Callaway's Design Requirements Procedure for HDPE Piping

Mohan –

Have you thought about this and/or discussed it with the appropriate staff person? I'd like to discuss this with you today (Tuesday, June 16) if that is OK with you.

- Tom Elwood

From: Elwood, Thomas B
Sent: Thursday, June 04, 2009 7:37 PM
To: 'Mohan Thadani'
Cc: Maglio, Scott A; Brandes, Matthew D
Subject: Issue to Discuss with NRC re Change to Callaway's Design Requirements Procedure for HDPE Piping

Mohan –

As you and I have discussed this week, the e-mail provided below was sent to me by the Project Engineer for our HDPE piping replacement in the ESW system. He has identified the need for a clarification (described below, and which you and I have briefly discussed) to be made in our design requirements procedure for the HDPE piping in our ESW system. The design requirements procedure is based on (i.e., is essentially the same as) a document provided in connection with our relief request and which was revised, finalized and provided as Enclosure 5 to ULNRC-05517 dated July 10, 2008. Because our procedure is essentially the same as the noted document provided to you on the docket, and because we are making this clarification to our procedure, we felt we should discuss this clarification with you before making the change. We think you'll agree that no letter or change to what was previously submitted is required. I believe Pani was the principle reviewer for this aspect of our HDPE relief request, so you might want to consult with him on this. We'd be happy to set up a phone call if you think one is needed.

- Tom Elwood

From: Brandes, Matthew D
Sent: Monday, June 01, 2009 11:32 AM

To: Elwood, Thomas B
Cc: Wilson, Randall; Abel, Shannon L; Fortman, Joseph L
Subject: Input to NRC for CARS 200902327

Tom,

As we have previously discussed, resolution to CARS 200902327 might need NRC interaction. I have attached my proposed changes to APA-ZZ-00662 Appendix F.

I have provided a brief description of the problem below for your consideration prior to communicating with the NRC:

++++++++++++++++++++

CARS 200902327 highlights that an error likely situation exists within Revision 4 of Appendix F of APA-ZZ-00662 concerning the design calculation formula for HDPE pipe Ring Deflection. APA-ZZ-00662, Appendix F, Requirements for High Density Polyethylene (HDPE) Piping for Nuclear Service, includes a calculation for ring deflection in Section 3031. Ring Deflection is defined as the change in pipe diameter resulting from soil pressure and is typically expressed in terms of change in pipe diameter as a percent of the original diameter.

The formula given in Section 3031 of Appendix F of APA-ZZ-0662 for "ring deflection" yields a unit-less number which is, in reality, deflection per inch of diameter (this number must be multiplied by the diameter of the pipe to yield pipe deflection) and compares the result to the "maximum allowable ring deflection". The applicable definition of terms in Section 3010 of Appendix F defines "Max Ring Deflection" as the "maximum allowable change in diameter expressed as a percent of the original diameter". Essentially, the formula leads one to compare ring deflection expressed as a ratio (pipe deflection per inch of diameter) to the maximum ring deflection expressed as a percentage. The potential error could be a factor of 100 times the allowable ring deflection.

Note that the calculation HAS been properly applied in the Callaway ESW piping design; however this slight clarification is being requested to prevent potential improper future usage.

Revision of Appendix F of APA-ZZ-00662 to clarify the error-likely situation described above would alter the revision date of the document such that it would be different than the date of the document provided as Enclosure 5 to ULNRC-05517 (dated July 10, 2008).

Licensing may want to discuss this with the NRC to determine if any additional actions (such as a clarification letter) are needed.

The due date for CAR 200902327 is June 17 (2009).

Thanks
-Matt

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REQUIREMENTS FOR HIGH DENSITY POLYETHYLENE (HDPE) PIPING FOR NUCLEAR SERVICE

TABLE OF CONTENTS

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REQUIREMENTS FOR HIGH DENSITY POLYETHYLENE (HDPE) PIPING FOR NUCLEAR SERVICE

AmerenUE Callaway Plant

-1000 GENERAL REQUIREMENTS

-1100 SCOPE

(a) This document contains rules for the construction of Class 3 high density polyethylene (HDPE) pressure piping and fittings. Use of these materials is permitted only for buried Emergency Service Water Systems that are classified as ASME Section III Class 3. The design pressures and temperatures of the various lines to be replaced will be 161 psig at 95°F, 160 psig at 95 °F, or 45 psig at 175 °F, as applicable to the specific line.

(b) Terms relating to polyethylene as used in this document are defined in Supplement 1.

-1200 QUALIFICATION OF SUPPLIERS

Qualification

(a) The PE material shall be procured from a qualified supplier as follows;

(1) AmerenUE shall be responsible for surveying, qualification, and auditing of the Nonmetallic Material Manufacturer and the Nonmetallic Material Constituent Supplier based on the survey and audit results of the Nonmetallic Material Manufacturer. Alternately, AmerenUE shall audit and qualify the Nonmetallic Material Manufacturer for surveying/auditing the Nonmetallic Material Constituent Supplier as permitted by ASME Section III NCA-3125 and NCA-3820.

(a) The survey and audit of the Nonmetallic Material Manufacturer will establish the following;

1. Verification process of constituent material chemistry, and
2. Quality System Program conforms to NCA- 3900.

(b) When survey and audit of the Nonmetallic Material Constituent Supplier is required, the survey and audit shall evaluate the Quality System Program and the implementation of ASTM D-3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

(c) Satisfactory completion of the survey and audit will allow the Nonmetallic Material Manufacturer to supply material to AmerenUE for a period of three years. After the three year period an audit shall be performed to assure continued program maintenance.

(b) AmerenUE shall perform any of the functions required by their respective Quality Assurance Program which are not performed by the Nonmetallic Material Manufacturer. AmerenUE may elect to perform any other Quality Program functions, which would normally be the responsibility of the Nonmetallic Material Manufacturer. These functions shall be clearly defined in the AmerenUE Quality Assurance Program.

c) AmerenUE shall make all necessary provisions so that the Authorized Inspection Agency can make the inspections necessary to comply with this document.

-1210 PE Procurement Chain

(a) When the Quality System surveys/audits required by -1200 have been completed, AmerenUE shall establish a qualified HDPE supply chain.

(1) The Nonmetallic Material Constituent Supplier is the organization which manufactures and certifies the base HDPE material pellets.

(2) The Nonmetallic Material Manufacturer is the organization which manufactures, and certifies HDPE material in compliance with requirements of this document. He shall perform or shall supervise and directly control one or more of the operations which affect the HDPE material properties capable to meet the requirements of the basic material specification, and shall verify the satisfactory completion of all other requirements performed by other organizations prior to his certification.

(3) The Nonmetallic Material Supplier is an organization which supplies products of the Nonmetallic Material Manufacturer but does not perform any operations which affect the HDPE materials properties required by the basic material specification.

(4) Certification to the requirements of ASME Code Case N-755 will be considered equivalent to certification to this document.

(b) All pressure retaining HDPE material used in construction of components shall be supplied with a certified certificate of analyses for batch (CCAB) or product quality certification (PQC). These documents shall include all the results of analysis and production tests performed on the HDPE material.

(1) Nonmetallic Material Constituent Supplier - Certified Certificate of Analysis for Batch or Product Quality Certification shall include HDPE material identification, physical property test results, and melt index temperature when required by AmerenUE when the approved Nonmetallic Material Manufacturer program relies on audits and certification.

(2) Nonmetallic Material Manufacturer - Certified Analysis for Batch or Product Quality Certification shall include HDPE material identification, physical property test results (includes all in-situ and final tests), melt index temperature, mechanical property test results, and shall certify that the product was made from virgin pellets (no scrap or regrind material). The product form shall be permanently marked.

-2000 MATERIALS

-2100 GENERAL REQUIREMENTS FOR MATERIALS

-2110 Scope

(a) All HDPE material and components shall be procured using the requirements of this document and the following additional requirements.

(1) HDPE material shall be selected from approved ASTM standards listed in Supplement 2, and shall have material properties not less than those for cell classification 445574C per ASTM D 3350-05 (PE 4710). The material may contain a color stripe with cell classification 445574E. (There is no physical difference between C and E other than color.)

(2) Only HDPE pipe, mitered elbows, and flanges of nominal size 4 NPS (DR9) and 36 NPS (DR9.5) using Carbon Black pigment shall be used.

(3) All HDPE product forms (pipe, mitered elbows, and flanges) shall conform to the ASTM Standards identified in Supplement 2, as applicable.

(b) HDPE material shall be marked in accordance with the marking requirements of the ASTM specified for the material, as applicable. If required the HDPE material shall be marked for identification purposes using a metallic paint marker or stenciling marker.

(c) All metallic materials and components shall be procured using the requirements of ASME Section III, Subsection ND.

-2200 ADDITIONAL PRODUCT FORM REQUIREMENTS

-2210 Mitered Elbows

The elbow fabricator shall be covered under the AmerenUE Quality Assurance Program. AmerenUE shall provide the services of an Authorized Nuclear Inspector. AmerenUE shall ensure the following requirements are met.

(a) All HDPE pipe material used shall comply with -2110(a).

(b) The configuration of the mitered elbow shall meet the requirements of –3022.4.

(c) All fabrication processes used in the fabrication of the mitered elbow shall meet the requirements of –4000 and Supplement 9.

(d) Mitered elbows shall have the fused joints inspected and accepted in accordance with –5000.

(e) A code data report shall be used for this product form (Supplement 4). Multiple assemblies may be included on a single form.

-2220 Transition Flange

(a) The pressure rating of the transition flange shall be equal to or greater than the attached straight pipe.

(b) The material cell classification shall be not less than 445574C per ASTM D 3350-05 (PE 4710).

-2300 EXAMINATION AND REPAIR OF MATERIAL

-2310 Receipt Examination

(a) All HDPE material external surfaces shall be given a visual examination prior to installation. Any indentation or flaw more than 10% of the minimum wall thickness for 4 NPS piping, and more than 7% for 36 NPS piping, regardless of wall thickness, shall be unacceptable. Additionally, for any flaw that will result in a remaining wall thickness less than the required as-fabricated minimum wall thickness per ASTM F714 shall be unacceptable unless evaluated and determined to be acceptable considering the remaining wall thickness. Lesser flaws shall be evaluated in accordance with -2320.

(b) Personnel performing the examination shall be qualified in accordance with -5000 of this document.

-2320 Repair of Material

(a) For all piping, any section with a flaw not exceeding 5% of the wall thickness and not resulting in a remaining wall thickness less than the required as-fabricated minimum wall thickness per ASTM F714 may be left as is.

(b) For all other flaws, the damaged section of pipe shall either be physically removed, or shall be repaired as follows:

(1) The depression after flaw elimination is blended uniformly into the surrounding surface with a maximum taper not to exceed 3:1 (width to height).

(2) After flaw elimination the area will be inspected by visual examination to ensure that the flaw has been removed.

(3) If elimination of the flaw reduces the thickness of the section below the minimum required design thickness, the section of piping containing the flaw shall be cut out and replaced.

(c) For flanges the following requirements shall be met;

(1) if the damaged area is in the flange section the entire flange shall be replaced, and

(2) if the damaged area is in the pipe section the section shall be removed or repaired as required by (a) and (b), above.

-3000 DESIGN

-3001 Scope

The design rules of this Section are limited to buried, high density polyethylene piping systems constructed of straight pipe, one, three and five-joint mitered elbows not exceeding 22-1/2 degrees per miter, fusion joints, and flanged connections.

-3010 Nomenclature

A	=	cross-section area of pipe at the pipe section where the evaluation is conducted, in^2
B_d	=	trench width, ft
B'	=	burial factor
c	=	the sum of mechanical allowances and erosion allowance, in
D	=	pipe outside diameter at the pipe section where the evaluation is conducted, in
D_{avg}	=	average pipe diameter in accordance with ASTM F-714
DR	=	dimension ratio of pipe = mean diameter divided by the minimum fabricated wall thickness = $D_{avg} / t_{fab\ min}$
E_{pipe}	=	modulus of elasticity of pipe, psi, Table 3031-3
E'	=	modulus of soil reaction, psi (Data is site specific)
E'_N	=	modulus of soil reaction of native soil around trench, psi (Data is site specific)
F_a	=	axial force due to the specified Design, Service Level A, B, C, or D applied mechanical loads, lb
F_{aC}	=	axial force range due thermal expansion and/or the restraint of free end displacement, lb
F_{aD}	=	axial force due to the non repeated anchor motion, lb
F_{aE}	=	axial force range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, lb
F_b	=	upward force per unit length, lb/ft
F_S	=	soil support factor, Table 3031-2
f_o	=	ovality correction factor, Table 3033.2-1
H	=	height of ground cover, ft
H_{gw}	=	height of water table above pipe, ft
K	=	bedding factor = 0.1
L	=	deflection lag factor, 1.25 to 1.50, or 1.0 if using the soil prism pressure
i	=	stress intensification factor, Table 3042-1
M	=	resultant moment due to the specified Design, Service Level A, B, C, or D applied mechanical loads, in-lb
M_C	=	resultant moment range due thermal expansion and/or the restraint of free end displacement, in-lb
M_D	=	resultant moment due to the non repeated anchor motion, in-lb
M_E	=	resultant moment range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, in-lb
P	=	internal gage pressure coincident with given service level or loading, psi
P_D	=	internal design gage pressure at the specified design temperature, psi
P_E	=	vertical soil pressure loads due to weight cover of earth, lb/ft^2
P_{hydro}	=	external hydrostatic pressure, equal to earth plus groundwater pressure plus surcharge load, psi
P_L	=	vertical soil pressure due to surcharge loads, lb/ft^2
R	=	buoyancy reduction factor
S	=	allowable stress, psi, Table 3021-1
T_D	=	Design Temperature, deg F

 INFORMATION USE

t = nominal pipe wall thickness, in
t_{design} = minimum required wall thickness, in
$t_{fab\ min}$ = minimum thickness in accordance with ASTM F-714
t_{min} = pressure design thickness, in
W_c = weight of contents (equals 0 when empty), lb/ft
W_P = weight of pipe per unit length, lb/ft (exclude weight of contained liquid to represent the worst case of an empty pipe)
W_w = weight of water displaced by pipe, per unit length, lb/ft
α = coefficient of thermal expansion, 1/°F
σ_{sw} = circumferential compressive stress in the sidewalls, psi
ΔP = differential pressure due to negative internal pressure, psi
ΔT_{eq} = equivalent temperature rise, deg.F
ε_{soil} = maximum soil strain due to seismic wave passage
Ω = ring deflection, expressed as a unit-less value of deflection per inch of diameter
Ω_{max} = maximum allowable change in diameter as a percent of the original diameter, commonly called the change in ring diameter, Table 3031-1
$\rho_{saturated}$ = density of saturated soil, lb/ft^3
ρ_{dry} = density of dry soil, lb/ft^3
ν = Poisson ratio (0.35 for short duration loads (5 min. or less) to 0.45 for long duration loads (greater than 5 min.))

-3012 Design Life

(a) The Design Specification shall specify the design life of the system, not to exceed 50 years.

(b) The duration of load shall be specified for each load case, and the HDPE pipe physical and mechanical properties shall be based on the duration of load.

-3016 Design and Service Loading

Design loads shall be as defined in ASME Section III, ND-3112.1 through ND-3112.3, except the design factor shall be 0.50. Miner's Rule in accordance with ISO 13760 shall be used to account for operation for 30 days at post-accident conditions and normal operating conditions for the balance of the 40 year design life. Loads applied to buried HDPE pipe shall be defined in the Design Specification, and shall include, as a minimum, the following:

(a) Maximum and minimum internal design gage pressure P_D, for pressure design in accordance with paragraphs -3021 and -3022.

(b) Maximum and minimum temperature T, for the selection of allowable stress (Tables 3021-1 and 3035-3) and design for temperature effects in accordance with paragraph –3040. The maximum Service Level A temperature shall be the Design Temperature, T_D.

(c) The stress limits for the loads resulting from the maximum flow velocity, v, shall be as provided in paragraph -3021.2.

(d) Vertical soil pressure P_E, including saturated soil, surcharge, buoyancy and flotation, for the designs in accordance with paragraph -3030.

(e) Vertical pressure due to weight of soil, P_E, and surcharge loads P_L for the design in accordance with paragraph -3030.

(f) Permanent ground movement, soil settlement, for design as non-repeated anchor movements in accordance with paragraph -3030.

(g) Seismic wave passage and, seismic soil movement and building anchor motions, for seismic design in accordance with paragraph -3050.

-3021 Pressure Design of Pipe

-3021.1 Minimum Required Wall Thickness. The minimum required wall thickness of straight sections of pipe for pressure design shall be determined by

$$t_{design} = t_{min} + c$$

t_{design} = minimum required wall thickness, in
t_{min} = pressure design thickness, in
c = the sum of mechanical allowances and erosion allowance, in

$$t_{min} = \frac{P_D D}{(2S + P_D)}$$

t_{min} = pressure design thickness, in
P_D = Piping system internal Design Pressure (gage) at the specified Design Temperature T_D, both being specified in the Piping Design Specification. This pressure does not include the consideration of pressure spikes due to transients, psi
D = pipe outside diameter at the pipe section where the evaluation is conducted, in
S = allowable stress, psi, per Table 3021-1

Table 3021-1 Allowable Design Stress, S, for PE4710 (Dow DGDA-2490/2492)*(psi)

Service	Load Duration					
Temperature	2 Years			50 Years**		
°F	0.50 DF	0.56 DF	0.63 DF	0.50 DF	0.56 DF	0.63 DF
73	Not Applicable			800	889	1000
86	Not Applicable			738	826	929
95	Not Applicable			695	778	875
104	Not Applicable			653	732	823
113	Not Applicable			613	687	773
122	Not Applicable			574	643	724
131	Not Applicable			537	601	676
140	Not Applicable			500	560	630
176	340	382	430	Not Applicable		

* Values not applicable to all materials.
** For service temperature 140 °F (60°C), use 50-year allowable design stress for service life 50-years.

-3021.2 Allowable Service Level Spikes due to Transients Pressures. The sum of the maximum anticipated operating pressure plus the maximum anticipated Level B pressure spikes due to transients shall be no greater than 1.5 times the piping system Design Pressure (see paragraph -3021.1). The sum of the maximum anticipated operating pressure plus the maximum anticipated Level C and D pressure spikes due to transients shall be no greater than 2 times the piping system Design Pressure (see paragraph -3021.1).

-3022 Pressure Design of Joints and Fittings

-3022.1 High density polyethylene pipe shall be joined using the butt fusion process. All connections to metallic piping shall be flanged joints.

-3022.2 Sustained pressure and pressure rating of high density polyethylene pipe fittings shall comply with the specifications listed in Supplement 2. The pressure rating of fittings shall be equal to or greater than the attached straight pipe.

-3022.3 Flanged connections shall include a metallic back-up ring and shall provide a leak tight joint up to and including the piping hydrostatic test pressure. In addition, the maximum surge pressure per –3021.2 shall not cause permanent deformation of the pipe.

-3022.4 Mitered elbows shall comply with the requirements of ASME Section III, ND-3644. In place of ND-3644 (e) butt fusion joints shall be used in accordance with this document. In addition, the mitered elbow segments shall be a minimum of one dimension ratio (DR) lower than that of the attached straight pipe. Heavier wall segments with larger outside diameter (i.e. “inverted” elbows) will be used for elbow fabrication to minimize flow restriction. 90 degree, 45 degree and 22-1/2 degree elbows are permitted. Elbows less than 90 degrees may have fewer than three miter joints.

-3030 Soil and Surcharge Loads

-3031 Ring Deflection. The soil and surcharge loads on a buried HDPE pipe shall not cause the pipe diameter to deflect (ring deflection, Ω) beyond a limit Ω_{max} where

CAUTION

The proper units **must** be used when comparing ring deflection expressed as a ratio (pipe deflection per inch of diameter) to the maximum ring deflection expressed as a percentage. Use of improper units could lead to a potential error that could be a factor of 100 times the allowable ring deflection.

$$\Omega = \frac{1}{144} \times \frac{K \times L \times P_E + K \times P_L}{\frac{2E_{pipe}}{3} \times \left(\frac{1}{DR-1}\right)^3 + 0.061 \times F_S \times E'} \leq \Omega_{max}$$

where

$$P_E = \rho_{saturated} \times H_W + \rho_{dry} \times (H - H_W)$$

K = bedding factor = 0.1
L = deflection lag factor, 1.25 to 1.50, or 1.0 if using the soil prism pressure
P_E = vertical soil pressure due to earth loads, lb/ft^2
P_L = vertical soil pressure due to surcharge loads, lb/ft^2
E_{pipe} = apparent modulus of elasticity of pipe at design life, psi
DR = dimension ratio of pipe
D = pipe outside diameter, in
t = nominal pipe wall thickness at the pipe section where the evaluation is conducted, in
F_S = soil support factor, Table 3031-2
E' = modulus of soil reaction, psi
E'_N = modulus of soil reaction of native soil around trench, psi
B_d = trench width, ft
$\rho_{saturated}$ = density of saturated soil, lb/ft^3
ρ_{dry} = density of dry soil, lb/ft^3
H = height of ground cover, ft
H_W = height of water table above pipe, ft

Table 3031-1 Maximum Allowable Ring Deflection HDPE

DR	Ω_{max} (%)
13.5	6.0
11	5.0
9	4.0
7.3	3.0

 INFORMATION USE

Table 3031-2 Soil Support Factor F_S

E'_N/E'	B_d/D					
	1.5	2.0	2.5	3.0	4.0	5.0
0.1	0.15	0.30	0.60	0.80	0.90	1.00
0.2	0.30	0.45	0.70	0.85	0.92	1.00
0.4	0.50	0.60	0.80	0.90	0.95	1.00
0.6	0.70	0.80	0.90	0.95	1.00	1.00
0.8	0.85	0.90	0.95	0.98	1.00	1.00
1.0	1.00	1.00	1.00	1.00	1.00	1.00
1.5	1.30	1.15	1.10	1.05	1.00	1.00
2.0	1.50	1.30	1.15	1.10	1.05	1.00
3.0	1.75	1.45	1.30	1.20	1.08	1.00
5.0	2.00	1.60	1.40	1.25	1.10	1.00

Table 3031-3 Modulus of Elasticity of HDPE Pipe (ksi)

Load Duration	Temperature (°F)				
	≤73 °F	100 °F	120 °F	140 °F	175 °F
< 10 h	110	100	65	50	na
10 h	58	47	31	24	na
100 h	51	42	27	21	na
1000 h	44	36	23	18	na
1 y	38	31	20	16	na
10 y	32	26	17	13	na
50 y	28	23	15	12	12

-3032 Compression of Sidewalls. The circumferential compressive stress in the sidewalls σ_{sw} due to soil and surcharge loads shall not exceed

$$\sigma_{sw} = \frac{(P_E + P_L) \times DR}{2 \times 144} \leq S$$

σ_{sw} = circumferential compressive stress in the sidewalls of pipe and miters, psi
P_E = vertical soil pressure due to earth loads, lb/ft^2
P_L = vertical soil pressure due to surcharge loads, lb/ft^2
DR = dimension ratio of pipe
S = allowable stress, psi, Table 3021-1

INFORMATION USE

-3033 External Pressure

-3033.1 Buckling Due to External Pressure. External pressure from ground water, earth loads, and surcharge loads on a buried HDPE pipe shall not cause the pipe to buckle.

$$[P_{hydro} = (P_E + P_L + P_{gw})] / 144 \leq 2.8 [R \times B' \times E' \times E_{pipe} / 12 (DR - 1)^3]^{1/2}$$

P_E = vertical soil pressure due to earth loads, lb/ft^2
P_L = vertical soil pressure due to surcharge loads, lb/ft^2
P_{gw} = pressure due to ground water, lb/ft^2
R = buoyancy reduction factor
E_{pipe} = modulus of elasticity of pipe, psi
E' = soil modulus, psi
DR = dimension ratio of pipe
B' = burial factor

and the buoyancy and burial factors are

$$R = 1 - 0.33 \times \frac{H_{gw}}{H}$$

$$B' = \frac{1}{1 + 4 \times \exp(-0.065 \times H)}$$

H_{gw} = height of ground water above pipe, ft
H = depth of cover, ft

Table 3033.2-1 Ovality Correction Factor

Per Cent-Ovality	1%	2%	3%	5%	6%
Ovality Correction Factor	0.91	0.84	0.76	0.64	0.59

-3034 Flotation. Buried HDPE pipe shall have sufficient cover or be anchored to the ground to prevent flotation by groundwater. The upward resultant force due to buoyancy on a buried pipe in saturated soil is

$$W_W < W_P + P_E \times D/12$$

W_w = weight of water displaced by pipe, per unit length, lb/ft
W_P = weight of empty pipe per unit length, lb/ft
P_E = vertical soil pressure due to earth loads, lb/ft^2
D = pipe outside diameter, in

 INFORMATION USE

-3035 Longitudinal Stress Design

-3035.1 Longitudinal Applied Mechanical Loads, Longitudinal stresses due to axial forces and bending moments resulting from applied mechanical loads shall not exceed k x S where

$$B_1 \times \frac{P_a \times D}{2 \times t} + 2 \times B_1 \times \frac{F_a}{A} + B_2 \times \frac{M}{Z} \leq k \times S$$

B_1 = stress index, Table 3035-1
B_2 = stress index, Table 3035-1
P_a = Design or Service Level A, B, C, or D pressure, psi
D = outside pipe diameter at the pipe section where the evaluation is conducted, in
t = nominal pipe wall thickness at the pipe section where the evaluation is conducted, in
F_a = axial force due to the specified Design, Level A, B, C, or D applied mechanical loads, lb
A = cross section area of pipe wall at the pipe section where the force is calculated, in^2
M = resultant bending moment due to the specified Design, Level A, B, C, or D applied mechanical loads, in-lb
Z = section modulus of pipe cross section at the pipe section where the moment is calculated, in^3
k = factor from Table 3035-2
S = allowable stress, psi, Table 3021-1

Table 3035-1 Stress Indices

	DR 7	DR 9	DR 11	DR 13.5
B_1 Straight and Butt Fused Joint	0.5	0.5	0.5	0.5
B_2 Straight and Butt Fused Joint	1.0	1.0	1.0	1.0
B_1 Miter (a)	0.69	0.69	0.69	0.69
B_2 Miter (a)	1.38	1.64	1.91	2.21

(a) Mitered elbows shall not exceed 22.5 deg. per segment.

Table 3035-2 Design and Service Level Longitudinal Stress Factors

Service Level	Design	A	B	C	D
Factor k	1.0	1.0	1.1	1.33	1.33

-3035.2 Short Duration Longitudinal Applied Mechanical Loads. Alternatively, for the assessment of short duration loads (less than five minutes), the allowable stress S may be replaced by 40% of the tensile strength at material yield. The method for determination of the tensile strength at material yield are given in ASTM D 638 Standard Test Method for Tensile Properties of Plastics. For cell classification 445474C, short duration allowable stress values have been determined and are provided in Table 3035-3.

Table 3035-3 Short-Duration Allowable Stress Values

Temp (°F)	≤70	100	120	140	175
S (psi)	1200	940	770	630	400

-3040 Temperature Design

-3041 Minimum Temperature. The high density polyethylene material shall not be used at a temperature below the manufacturer limit, but in no case shall the temperature be less than minus 50°F.

-3042 Design for Expansion and Contraction

-3042.1 Fully Constrained Thermal Contraction. The tensile stress resulting from the assumption of fully constrained thermal contraction of the buried pipe when $T_{water} < T_{ground}$, increased by the tensile stress due to axial contraction from Poisson effect, shall not exceed the allowable stress S.

$$\sigma_\tau = \left| E_{pipe} \times \alpha \times \Delta T - \upsilon \times \frac{P \times D}{2 \times t} \right| \leq S$$

S = allowable stress, psi
α = coefficient of thermal expansion, 1/°F
ΔT = $T_{water} - T_{ground} < 0$
ν = Poisson ratio (0.35 for short duration loads to 0.45 for long duration loads)
E_{pipe} = modulus of elasticity of pipe, psi, Table 3031-3
P = internal design gage pressure, psi, including pressure spikes due to transients from anticipated waterhammer events
D = pipe outside diameter, in
t = nominal wall thickness, in

-3042.2 Fully Constrained Thermal Expansion. The tensile stress resulting from the assumption of fully constrained thermal expansion of the buried pipe when $T_{water} > T_{ground}$, shall not exceed the allowable stress S.

$$\sigma_\tau = E_{pipe} \times \alpha \times \Delta T \leq S$$

S = allowable stress, psi
α = coefficient of thermal expansion, 1/°F
ΔT = $T_{water} - T_{ground} > 0$
E_{pipe} = modulus of elasticity of pipe, psi, Table 3031-3

-3042.3 Alternative Thermal Expansion or Contraction Evaluation. As an alternative to -3042.1 and -3042.2, the soil stiffness may be accounted for to calculate pipe expansion and contraction stresses. The stresses shall satisfy the following equation using the same differential temperatures as used in the fully constrained evaluations

$$\frac{iM_C}{Z} + \frac{F_{aC}}{A} \leq 1100 \text{ psi}$$

I = stress intensification factor, Table 3042.2-1
F_{aC} = axial force range due thermal expansion or contraction and/or the restraint of free end displacement, lb
A = cross-section area of pipe at the pipe section where the force is calculated, in^2
M_C = resultant moment range due thermal expansion or contraction and/or the restraint of free end displacement, in-lb
Z = section modulus of pipe cross section at the pipe section where the moment is calculated, in^3

Table 3042.2-1 Stress Intensification Factor i

Fitting or Joint	i
Straight Pipe	1.0
Butt Fusion	1.0
Mitered Elbows	2.0

-3043 Non-Repeated Anchor Movements

The effects of any single non-repeated anchor movements shall meet the requirements of the following equation

$$\frac{iM_D}{Z} + \frac{F_{aD}}{A} < 2S$$

I = stress intensification factor, Table 3042.2-1
F_{aD} = axial force due to the non repeated anchor motion, lb
A = cross-section area of pipe at the pipe section where the force is calculated, in^2
M_D = resultant moment due to the non repeated anchor motion, in-lb
Z = section modulus of pipe cross section at the pipe section where the moment is calculated, in^3
S = allowable stress, psi, Table 3021-1

-3050 Seismic Design

-3051 Seismic Induced Stresses

The stresses in the buried PE piping system due to soil strains caused by seismic wave passage, seismic soil movement, and building seismic anchor motion effects, where applicable, shall be evaluated. The stresses shall satisfy the following equation

$$\frac{iM_E}{Z} + \frac{F_{aE}}{A} \leq 1100 \text{ psi}$$

i = stress intensification factor, Table 3042.2-1
F_{aE} = axial force range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, lb
A = cross-section area of pipe at the pipe section where the force is calculated, in^2
M_E = resultant moment range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, in-lb
Z = section modulus of pipe cross section at the pipe section where the moment is calculated, in^3
S = allowable stress, psi, Table 3021-1

Seismic wave passage, seismic soil movement, and building seismic anchor motions shall be combined by square root sum of the squares or by algebraic sum.

Supplement 3 provides a non-mandatory method for the analysis of seismic wave passage, seismic soil movement, and building seismic anchor motion effects.

-3060 Design for Future Internal Access

Removable spools will be installed that would provide future access to the ID surfaces in each replacement line should suitable remote examination equipment be developed.

-4000 FABRICATION AND INSTALLATION

-4100 GENERAL REQUIREMENTS

-4110 Scope

This Article provides the requirements for the installation of PE piping and fittings. Methods of installation shall be by thermal fusion and flanged fittings. Use of threaded or adhesive joints with HDPE material is not permitted. All metallic interface components will be installed following the requirements of ASME Section III, Subsection ND.

-4120 Examinations

[Deleted]

-4130 REPAIR OF MATERIAL

HDPE material originally accepted on delivery in which defects exceeding the limits of -2300 are known or discovered during the process of fabrication or installation is unacceptable. The HDPE material may be used provided the defective area can be physically removed from the material or repaired in accordance with -2300.

-4200 CUTTING, FORMING, AND BENDING

-4210 Cutting

Materials may be cut to shape and size by mechanical means such as machining or cutting.

-4220 Forming and Bending Processes

The HDPE material shall not be cold or hot formed or bent. A pipe bending radius greater than or equal to 30 times the pipe outside diameter is acceptable for piping with a DR 9 through 13.5 and is considered to be straight pipe.

-4300 FUSING QUALIFICATIONS

-4310 General Requirements

(a) Fusing procedure and machine operator performance qualification shall comply with the requirements of Supplement 9.

(b) The Thermal Fusion Butt Joint is the only thermal fusion joint allowed, see Figure –4310-1.

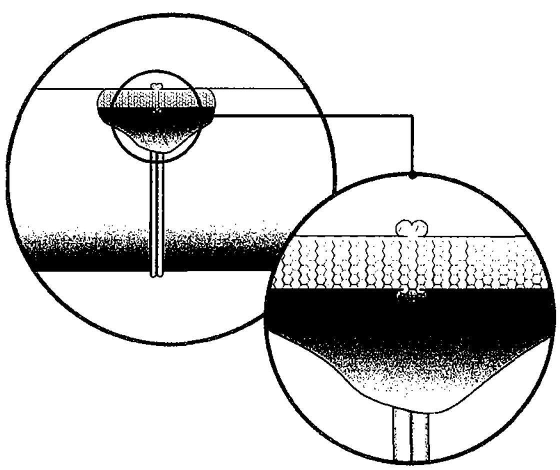


FIGURE -4310-1 Thermal Fusion Butt Joint

 INFORMATION USE

-4320 Qualifications

-4321 Required Qualifications

AmerenUE shall be responsible for all fusing performed for this project and shall establish the procedures, and conduct the tests required by Supplement 9 to qualify fusion machine operators who apply these procedures.

-4322 Maintenance and Certification of Records

AmerenUE shall maintain records of qualified fusing procedures and the fusion machine operators qualified by them, showing the date and results of tests and the identification mark assigned to each fusing operator. These records shall be reviewed, verified, and signed by an authorized individual and they shall be accessible to the Authorized Nuclear Inspector.

-4323 Fusing Prior to Qualification

Fusing Procedure Specification (FPS) shall be qualified as required by Supplement 9 prior to their use. Only fusing operators who are qualified in accordance with -4320 and Supplement 9 shall be used.

-4324 Transferring Qualifications

The FPS qualifications and performance qualification tests for fusion machine operators shall not be transferred to another organization.

-4330 Requirements for Fusing Procedure Qualification Tests

-4331 Conformance to Supplement 9 Requirements

All fusing procedure qualification tests shall be in accordance with the requirements of Supplement 9 as supplemented or modified by the requirements of this document.

-4332 Preparations of Test Coupons and Specimens

Removal of test coupons from the fusion test coupons and the dimensions of specimens made from them shall conform to the requirements of Supplement 9.

-4340 Performance Demonstration

-4341 AmerenUE will produce six (6) fusion joint test coupons of 36NPS DR 9.5 and six (6) fusion joint test specimens of 4NPS DR 9 material on each model of fusion machine carriage expected to be used in production for the respective size of piping as a performance demonstration. Three (3) of these fusions on each machine will target minimum temperature and interfacial pressure using maximum heater removal times, and three (3) will target maximum temperature and interfacial pressure using minimal heater removal times – considering production limits, machine capabilities and the limits of the AmerenUE Fusion Procedure Specification.

-4342 A minimum of four (4) specimens will be cut from each fusion joint coupon approximately 90 degrees apart and tensile-tested to verify that the fusion joint is stronger than the pipe. Testing will be performed by commercial plastics industry suppliers without a 10 CFR 50 Appendix B quality program, but all testing will be overseen by AmerenUE representatives, and the test records will be retained in permanent Callaway records.

-4343 High speed impact tensile testing for the 4 NPS and 36 NPS specimens will be performed in accordance with QF-131. If this testing is determined to be inconclusive for the 36 NPS specimens due to fast tensile machine capability and the need to test segmented specimens, tensile testing for the 36 NPS specimens will be performed with full-section specimens consistent with ASTM Specification D638, "Standard Test Method for tensile Properties of Plastic."

-4400 RULES GOVERNING MAKING FUSED JOINTS

-4410 General requirements

-4411 Identification, Storage, and Handling of HDPE Materials

AmerenUE is responsible for control of the HDPE materials that are used in the fabrication and installation of components (-4120). Suitable identification, storage, and handling of HDPE material shall be maintained.

-4412 Cleanliness and Protection of Surfaces to Be Fused

The surfaces of the heater used for fusing shall be free of scale, rust, oil, grease, and other deleterious material. The work shall be protected from deleterious contamination and from rain, snow, and wind during fusing operations. Fusing shall not be performed on wet surfaces. Fusing will not be performed below 50 deg F. Any fusing performed below ambient temperature of 50°F will require an environmental enclosure to be placed over the work area to control temperature.

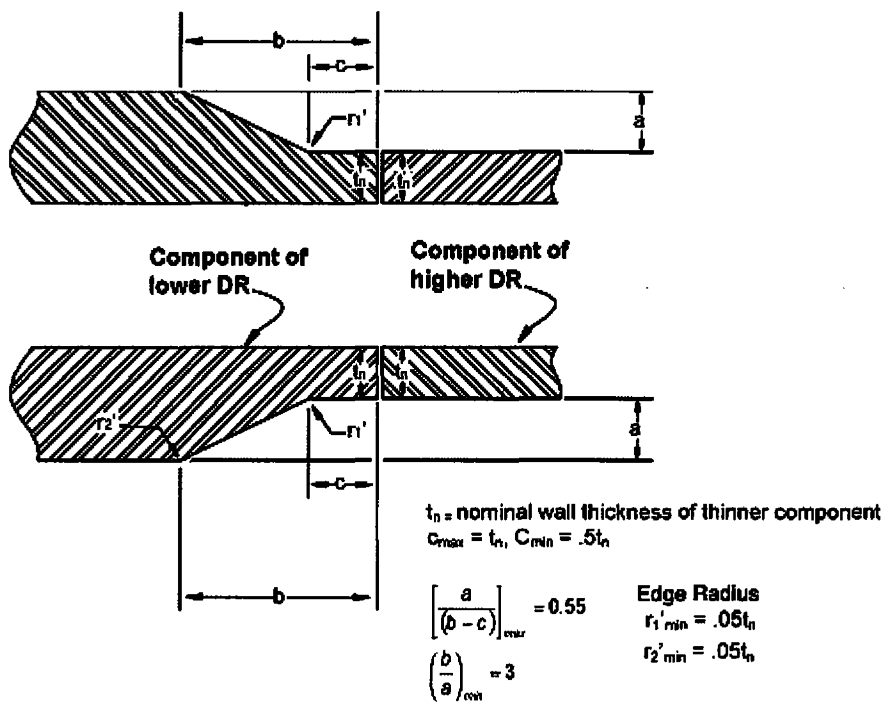
-4420 Rules For Making Fused Joints

-4421 Fused Joint Fit-up Requirements

(a) Components of different outside diameters shall not be fused together.

(b) The alignment of components for open butt fusion joints will be held in position by the fusing machine, allowable surface mismatch shall be less than 10% of the minimum wall thickness of the components being fused, and the remaining joint thickness shall not be less than the required as-fabricated minimum wall thickness per ASTM F714 – unless evaluated and determined to be acceptable considering the remaining wall thickness.

c) To fuse components with differing DR's, the component with the smaller DR shall be countered-bored and tapered to meet the wall thickness of the component with the larger DR and shall comply with Figure-4421.3-1.



Transition Counter-bore

FIGURE 4421.3-1

-4422 Identification of Joints by Fusing Operator

Each fusing operator shall apply the identification mark assigned to him adjacent to all permanent fused joints or series of joints on which he fuses. The marking shall be 1 ft (.3 m) or less from the fusion bead and shall be done with permanent metallic paint marker or stenciling marker.

-4423 Repairs

Repair of a fused joint is not allowed. All unacceptable joints shall be cut out and replaced.

-4430 Fusing Data Acquisition Recorder

The fusion machine shall have an automatic acquisition data recorder attached to it. The recorder shall record essential variables of the fusion process.

(a) Failure to run the recorder during the fusion process shall be cause to fail the fusion joint.

(b) The butt fusion joint record should be compared to the FPS to ensure that the proper butt fusion parameters and procedures were followed. If any parameter is out of the approved range, the fused joint shall be cut out and remade using the correct FPS.

-4500 ASSEMBLY AND ERECTION

-4510 General

Any distortion of piping to bring it into alignment for joint assembly which introduces a permanent strain in the piping or associated piping components is prohibited.

-4520 Flanged Joints Using HDPE Material

(a) Flanged connections are only permitted for the joining of high density polyethylene pipe to metallic pipe or piping components. The flange connection shall be constructed using a high density polyethylene flange adapter having a DR ratio equal to or less than that of the attached HDPE pipe and shall be joined by fusion to the attached high density polyethylene piping.

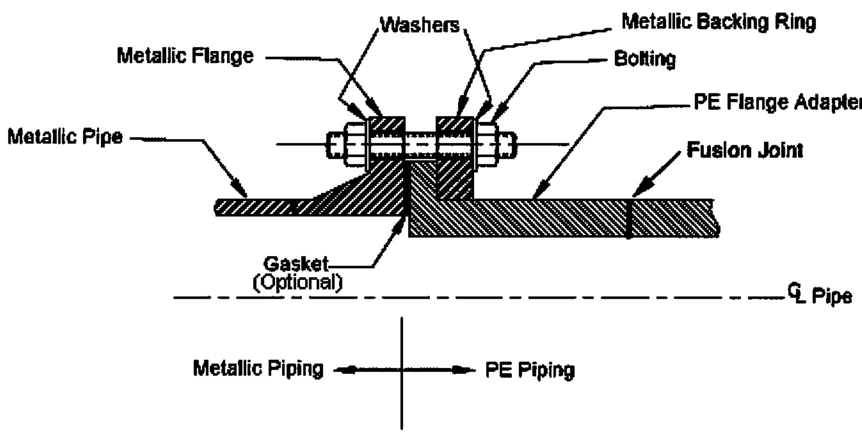
(b) The high density polyethylene flange adapter shall be connected to the metal flange using a metallic backing ring, The backing ring shall have a pressure rating equal to or greater than the metal flange.

(c) Following acceptable visual examination, the external fusion beads may be removed in order to accommodate installation of the metallic backing ring.

(d) Before bolting up, flange faces shall be aligned to the design plane within 1/16 in./ft measured across any diameter; flange bolt holes shall be aligned within 1/8 in. maximum offset. Damage to a gasket, if used, or seating surface on the HDPE flange which would prevent proper sealing shall be replaced per –2320(c).

(e) The flange shall be joined using bolts of a size and strength that conforms to the requirements of ASME B 16.5 or B16.47 as applicable. Bolts or studs should extend completely through their nuts. Any which fail to do so are considered acceptably engaged if the lack of complete engagement is not more than one thread. Flat washers shall be used under bolt heads and nuts.

(f) In assembling flanged joints, the gasket, or high density polyethylene flange face if a gasket is not used, shall be uniformly compressed to the proper design loading. Special care shall be used in assembling flanged joints in which the flanges have widely differing mechanical properties. The required HDPE flange joint seating stress and bolt torque will be determined in accordance with the guidance provided in PPI document Technical Note TN-38, "Bolt Torque for Polyethylene Flanged Joints." If used, gasket material shall be selected to be consistent and compatible with the service requirements of the piping system. No more than one gasket shall be used between contact faces in assembling a flanged joint. See Figure -4520-1 for a typical flange configuration.



Transition Flange Arrangement

FIGURE -4520-1

-4530 Pipe Supports

All installed HDPE pipe supports shall meet the requirements of Subsection NF and the following:

(a) Piping shall be supported, guided, and anchored in such a manner as to prevent damage to the piping. Point loads and narrow areas of contact between piping and supports shall be avoided. Suitable padding shall be placed between piping and supports where damage to piping may occur.

(b) Valves and equipment which would transmit excessive loads to the piping shall be independently supported to prevent such loads.

 INFORMATION USE

-5000 EXAMINATION

-5100 GENERAL REQUIREMENTS

(a) Visual examinations shall be conducted in accordance with the examination method of Section V, Article 9.

(b) All personnel qualified to perform Visual Examinations on HDPE pipe (VT-1 examinations), excluding the hydrostatic pressure test (VT-2 examinations), shall receive the same training as required for the fusion machine operator in Supplement 9. This training shall include the use of a fusion machine to make a fused joint; however this joint is not required to be tested for qualification. This training shall be documented on a training record.

(c) In addition, personnel performing VT-1 inspections shall undergo evaluation involving examination of physical samples of visually acceptable and unacceptable HDPE pipe fusion joints. A minimum of five flaw samples will be used for the visual examination procedure demonstration, and five for the personnel demonstration using the visual examination procedure.

-5110 Procedures

Examination Procedures. All examinations shall be executed in accordance with detailed written procedures which have been proven by actual demonstration, to the satisfaction of the Authorized Nuclear Inspector. Written procedures, records of demonstration of procedure capability, and personnel qualification shall be made available to the Authorized Nuclear Inspector on request.

-5120 Time of Examination of Completed Fused Joints

Visual examination of all fused joints shall be conducted;

(a) upon the completion of cooling period;

(b) after the review required by paragraph –4430 has been reviewed and accepted; and

(c) shall be completed before piping becomes inaccessible for inspection.

-5200 REQUIRED EXAMINATIONS

-5210 Visual Examinations are Required on the Following Material and Components

(a) During receipt inspection of the external surface for indentations.

(b) Fusion joints after the fusion process includes, review and verification of fusion data for the joint, and external surfaces. Joints that are not examined in accordance with -5220 shall be visually inspected on the interior of the joint, including the interior beads of mitered joints.

(c) All pipe fusion joints during the hydrostatic test.

-5220 Time-of-Flight Diffraction (TOFD) Examination

To provide added assurance of joint integrity, AmerenUE will perform ultrasonic Time-of-Flight Diffraction (TOFD) examination of all completed fusion joints, with the exception of portions of joints where the geometry prohibits effective examination (i.e., intrados and extrados areas of mitered fitting joints).

(a) This is a non-standard non-Code examination, and the contractor providing the service will not have a 10CFR50 Appendix B program. AmerenUE personnel will oversee the examinations.

(b) A demonstration will be performed to verify that the Time-of-Flight Diffraction (TOFD) procedure utilized will apply available technology for this technique. The demonstration will utilize specimen(s) containing ten flaws of varying shapes, dimensions and relative locations, simulating flaws expected to occur in unacceptable joints.

(c) Personnel performing TOFD examinations will be qualified in accordance with SNT-TC-1A (Level II, minimum) or equivalent, as determined by AmerenUE.

(d) Acceptance criteria will be evaluated and refined by AmerenUE, and will be based on industry standards (e.g. B31 piping codes). The current acceptance criteria require that any unbonded area in the joint, found as a result of the TOFD, is cause for rejection.

(e) All TOFD joint examination records shall be retained as permanent records.

-5300 ACCEPTANCE STANDARDS

-5310 General Requirements

Unacceptable joints shall be removed. Repair of unacceptable joints is not permitted.

-5320 Visual Examination Acceptance Criteria of External Surfaces

-5321 Thermal Fusion Butt Joints Shall Meet the Following:

(a) Joints shall exhibit proper fusion bead configuration, see Supplement 5.

(b) There shall be no evidence of cracks or incomplete fusion.

Except for mitered joints, joints shall not be visually angled or off-set. The ovality offset shall be less than 10% of the minimum wall thickness of the fused components provided the remaining joint thickness is not be less than the required as-fabricated minimum wall thickness per ASTM F714 - unless evaluated and determined to be acceptable considering the remaining wall thickness.

(c) The cleavage between fusion beads shall not extend to or below the outside diameter pipe surface (see Figure –5321-1).

(d) For mitered joints, the beads may flare out instead of roll back to the pipe surface, and/or may exhibit multiple beads or heavy beads with no cleavage. In either case, there must be evidence of melt flow around the complete interior and exterior circumference of the joint. Refer to Supplement 5.

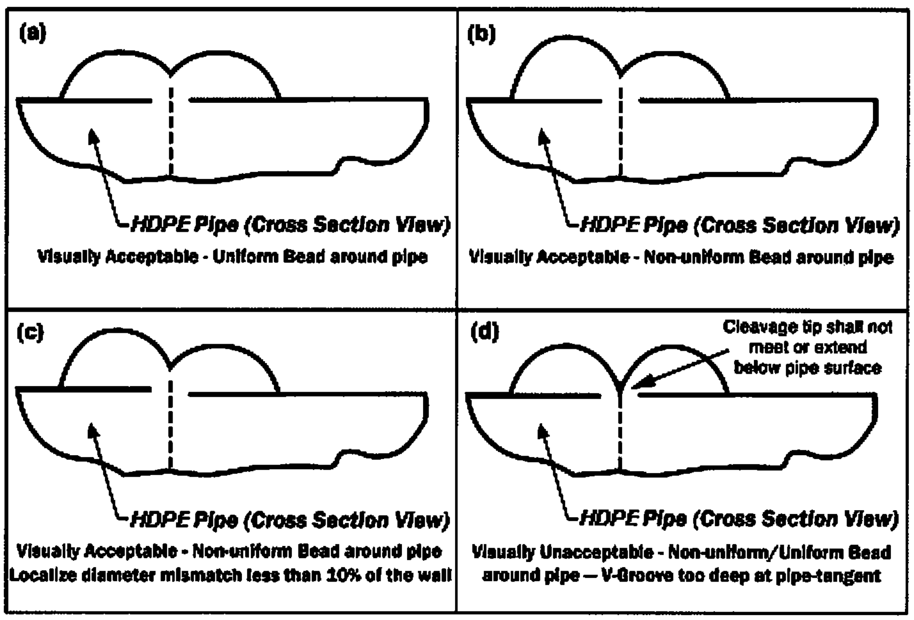


FIGURE -5321-1

(e) Review the data acquisition record for the joint and compare it to the Fusion Procedure Specification (FPS) to ensure the proper parameters and procedures were followed in making the fused joint, see paragraph –5330.

 INFORMATION USE

-5330 Process Verification

The data acquisition record for each joint shall be reviewed and compared to the Fusion Procedure Specification (FPS) to ensure the proper parameters and procedures were followed in making the fused joint.

-5500 QUALIFICATION OF NONDESTRUCTIVE EXAMINATION PERSONNEL

-5510 General Requirements

[Deleted]

-5520 Personnel Qualification Requirements

(a) Personnel performing visual examinations required by –5200 (a) and (b) shall be qualified and certified as a VT-1 in accordance with IWA-2000 and shall receive the required training and evaluation in paragraph –5100(b) & (c).

(b) Personnel performing visual examinations required by -5200(c) shall be qualified and certified as a VT-2 in accordance with IWA-2000 and receive four hours of training in PE piping and joining practices. This training shall be documented on a training record.

-6000 TESTING

-6100 GENERAL REQUIREMENTS

(a) Prior to initial operation, the installed system shall be hydrostatically tested in the presence of the Authorized Nuclear Inspector.

(b) All joints, including fused joints shall be left exposed for examination during the test. For long sections of piping the hydrostatic testing may be accomplished by testing in small sub-sections of the longer section. Upon a satisfactory test of each small section the piping may be buried. This process shall be documented in the AmerenUE Quality Assurance Program or Repair/Replacement Program and found acceptable to the Authorized Nuclear Inspector.

(c) The pressure in the test section shall be gradually (minimum rate of 5 psig/min not to exceed a maximum rate of 20 psig/min) increased to the specified test pressure and held for 4 hours. Make up water may be added to maintain test pressure during this time to allow for initial expansion. Following the 4 hour initial pressurization period, the test pressure shall be reduced by 10 psig and the system monitored for anther 1 hour. Make up water may no longer be added to maintain pressure. Each joint shall be examined. If no visual leakage is observed and the pressure remains within 5% of the test pressure for the 1 hour, the pipe section under test is considered acceptable.

(d) The temperature of the piping under test will be maintained within the temperature limits of the system design.

 INFORMATION USE

(e) The total test time including initial pressurization, initial expansion, and time at test pressure, must not exceed 8 hours. If the pressure test is not completed the test section shall be de-pressurized. The test section shall not be re-pressurized for at least 8 hours.

(f) A pneumatic test is not permitted.

-6200 Hydrostatic Test Requirements

(a) Instrumentation for the hydrostatic test shall be in accordance with IWA-5260.

(b) The minimum test pressure shall be 1.5 times the Design Pressure of the HDPE piping system plus 10 psi.

(c) Personnel qualified in accordance –5520(b) shall conduct the examination.

-8000 NAMEPLATES, STAMPING AND REPORTS

-8100 GENERAL REQUIREMENTS

-8110 Scope

The requirements for nameplates, stamping and reports shall be in accordance with AmerenUE's ASME Section XI Repair/Replacement Program with the following exception:

(a) Other than thermal indentation line printing during manufacture, no indentation stamping is allowed on the high density polyethylene pipe surface, all marking shall be performed with a metallic paint marker or stenciling marker.

(b) Form NM(PE)-2 (Supplement 2) shall be used for batch produced products produced by fusion (i.e., shop fabricated fittings). Multiple fittings may be included on one Data Report Form.

 INFORMATION USE

Supplement 1

Glossary

Sheet 1 of 2

1. Butt Fusion Cycle - Pressure/Time diagram for a defined fusion temperature, representing the butt fusion operation.

2. Certified Certificate of Analysis for Batch (CCAB) - A document attesting that material is in accordance with specified requirements, including batch analysis of all chemical analysis, test, and examinations.

3. Control Specimen - The specimen from the base material tested to determine the tensile strength for the purpose of determining an acceptable tensile strength.

4. Cool Time Under Pressure - In the fusion process, the theoretical fusion pressure plus drag pressure is applied between the pipe ends. This pressure must be maintained until the fusion joint is cool to the touch.

5. Coupon - A fusion assembly for procedure or performance qualification testing. The coupon may be any product from sheet plate, pipe, or tube material.

6. Data Acquisition Record - A detailed record of the times and pressures used in the fusion process along with the heater surface temperature , employee information, fusion machine information, pipe information, date and time for a permanent record of each joint made.

7. Drag Pressure - The pressure required by the fusion machine to overcome the drag resistance and frictional resistance and keep the carriage moving at its slowest speed.

8. Drag Resistance - Frictional resistance due to the weight of the length of pipe fixed in the movable clamp at the point at which movement of the moveable clamp is initiated (peak drag) or the friction occurring during movement (dynamic drag).

9. Frictional Resistance in the Butt Fusion Machine - Force necessary to overcome friction in the whole mechanism of the butt fusion machine.

10. Fusion Machine Operator - Person trained to carry out fusion joining between polyethylene (PE) pipes and/or fittings based on the Fusion Procedure Specification (FPS).

11. Fusion Operator Certificate - Approval certificate issued by the examiner/assessor stating the knowledge and the skill of the fusion operator to produce fusion joints following a given fusion procedure.

12. Fusion Procedure - A document providing in detail the required variables for the butt fusion process to assure repeatability in the butt fusion procedure (FPS).

13. Heater Bead-up Size - In the heating cycle, the pipe is brought against the heater and the force is dropped to the soak cycle. During this cycle, a bead of polyethylene is formed between the pipe end and the heater surface on both sides. When the bead-up size reaches the size established in the FPS, it is time to open the carriage and remove the heater.

Supplement 1 (Cont'd.)

Sheet 2 of 2

14. Heater Surface Temperature - The temperature, in degrees F, of the surface of the coated heater is critical to the butt fusion process. It is usually expressed as a range (example: 400 - 450° F) and the common practice is to set the average surface temperature at the mid-range (example: 425° F).

15. Hydrostatic Design Basis (HDB) - One of a series of established stress values for a compound.

16. Hydrostatic Design Stress (HDS) - The estimated maximum tensile stress the material is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

17. Interfacial Pressure - The amount of force in pounds (lbs) per square inch of pipe area required to calculate the fusion machine gauge pressure. The interfacial pressure is multiplied by the pipe area in square inches to determine the amount of fusion force (lbs) required to fuse the pipe. This force is divided by the total effective piston area of the hydraulic fusion machine to determine the theoretical gauge pressure to set on the fusion machine. The Drag pressure must be added to this pressure to determine the actual gauge pressure required for fusion. The interfacial pressure usually has a range (example: 60-90 psi) and the common practice is to use the mid-range (example: 75 psi) when making these calculations.

18. Long-Term Hydrostatic Pressure - Strength (LTHS) – the estimated tensile stress in the wall of the pipe in the circumferential orientation that when applied continuously will cause failure of the pipe at 100,000 hours.

19. Modulus of Soil Reaction, E' - The soil reaction modulus is a proportionality constant that represents the embedment soil's resistance to ring deflection of pipe due to earth pressure. E' has been determined empirically from field deflection measurements by substituting site parameters (i.e. depth of cover, soil weight) into Spangler's evaluation and "back calculating" E'.

20. HDPE (high density polyethylene) - A polyolefin composed of polymers of ethylene. It is normally a translucent, tough, waxy solid which is unaffected by water and by a large range of chemicals. This is one of three general classifications based on material density; low-density, medium-density, and high-density.

21. Product Quality Certification (PQC) - A document attesting that material is in accordance with specified requirements, including batch analysis of all chemical analysis, test, and examinations.

22. Stiffness Factor - The measurement of a pipe's ability to resist deflection as determined in accordance with ASTM D 2412.

23. Test Joint - Work pieces joined by fusing to qualify fusing procedures, or fusing operators.

24. Thermoplastic Resin - A resin material which does not react or polymerize and which flows with the application of heat and solidifies when cooled. A material which can be reformed.

Supplement 2

ASTM PE Material Standards

Sheet 1 of 1

The following PE materials standards are acceptable for use,

1. D-3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

2. D-3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

3. D-3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

4. F-714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

5. F-1055, Standard Specification for Electro fusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

6. F-2206, Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock, or Block Stock

Supplement 3

Non-Mandatory Method (Seismic Design)

Sheet 1 of 2

The buried pipe may be qualified by analysis for the effects of seismic wave passage, following the method provided in this Appendix.

Step-1. The strains from seismic wave passage, and seismically-induced permanent or temporary movements if any, shall be obtained by a plant-specific geotechnical-civil investigation.

Step-2. The soil strains (Section 3051) shall be converted into an equivalent temperature rise of the buried pipe, as follows

$$\Delta T_{eq} = \frac{\varepsilon_{soil}}{\alpha}$$

ΔT_{eq}= equivalent temperature rise, deg.F
ε_{soil} = maximum soil strain due to seismic wave passage
α = coefficient of thermal expansion of the pipe, $1/^{o}F$

Step-3. The pipe-soil system shall be modeled as a piping system constrained by soil springs.

(a) The pipe model shall consider two cases: short-term modulus (< 10 hours, Table 3031-3) for wave passage and long-term modulus for permanent soil movement (permanent seismic anchor motion).

(b) The soil model shall have at-least a bi-linear stiffness, and shall consider two cases: upper and lower bound of soil stiffness.

> For guidance on modeling soil-pipe interaction, refer to ASCE, Guidelines for the Seismic Design of Oil and Gas Pipeline Systems, 1984, ASCE 4 Seismic Analysis of Safety-Related Nuclear Structures and Commentary, or American Lifelines Alliance, Guidelines for the Design of Buried Steel Pipes, July 2001, with February 2005 addendum.

Step-4. The equivalent change of temperature ΔT_{eq} shall be applied to the pipe-soil model, to obtain forces and moments throughout the system.

Step-5. The anticipated building seismic anchor movements, if any, shall be applied to the pipe-soil model to obtain forces and moments throughout the system.

Step-6. The anticipated seismic movements, if any, shall be applied to the pipe-soil model to obtain forces and moments throughout the system.

Step-7. The results of Steps 4, 5, and 6 shall be combined by SRSS or algebraic sum, at each point along the piping system to obtain resultant forces and moments.

 INFORMATION USE

Supplement 3 (Cont'd.)

Sheet 2 of 2

Step-8. The resultant forces and moments shall be evaluated as follows:

(a) The axial stresses in pipe, fittings and fused joints shall comply with the requirements of 3051.

(b) Alternatively, the seismic induced strain shall be determined as follows:

$$(\varepsilon_a)_{Earthquake} = [\ |\sigma_E| + |\nu\,(PD / 2t)|\ ] / E$$

Where:

$(\varepsilon_a)_{Earthquake}$ = Strain in the pipe from earthquake wave computer analysis

This strain, $(\varepsilon_a)_{Earthquake}$ shall be limited to the values listed in Table A-1, where k is defined in Table 3035-2

Table A-1 Seismic Strain Limits

DR	Allowable Strain
DR ≤ 13.5	0.025 x k
13.5 < DR ≤ 21	0.020 x k
DR > 21	0.017 x k

Supplement 4

Forms

Sheet 1 of 4

1. Form NM(PE) -2, Data Report for Non-Metallic Batch Produced Products

2. Form QF-200, Fusion Procedure Specification (FPS)

3. Form QF-300, Fusion Machine Operator Qualification (FPQ)

Attachment 4 (Cont'd.)

Sheet 2 of 4

FORM NM(PE)-2 DATA REPORT FOR NON METALLIC BATCH PRODUCED PRODUCTS REQUIRING FUSING
As required by the Provisions of the AmerenUE 10CFR50.55a Request Number I3R-10

1. Manufactured by ______________________________
(Name and address of Manufacturer of Non Metallic products)
2. Manufactured for ______________________________
(Name and address of purchaser)

3. a) Identification- Certificate Holder's Serial No. ______________________
(Lot No., Batch No., etc.) (Print string)
____
(Nat'l Board No.) (yr. mfg.)

b) Owner ______________________________

4. Manufactured according to Mat'l Spec. ____________ Purchase Order No.____________________
(ASTM)
5. Remarks: ______________________________
(Brief Description of F____________

CERTIFICATE OF COMPLIANCE
We certify the statements made in this report are correct and the products defined in this report conform to the requirements of the ASME Material specification listed above on line 4. The Certified Material Batch Reports provided for the material covered by this report.
Date _________________, 20__ Signed ______________________By ______________________
ASME Certificate of Authorization (NA if Owner) No. ___________to use the ________ Symbol expires __________
(Date)

CERTIFICATE OF INSPECTION
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and the State or Province of ________________________and employed by
____
of ________________________________have inspected the products described in this Partial Data Report product in accordance with the ASME Section III, Division 1, AmerenUE 10CFR50.55a Request Number I3R-10.
By signing this certificate, neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the product described in this Partial Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date __________ 20__
____________________________Commissions______________________________________
(Inspector's Signature) National Board, State, Province and No.

*Supplemental sheets in form of lists, sketches or drawings may be used provided (1) size is 8 1/2 in. x 11 in. (2) information on items 1-4 on this Data Report is included on each sheet, and (3) each sheet is numbered and number of sheets is recorded at the top of this form.

Supplement 4 (Cont'd.)

Sheet 3 of 4

FORM QF-200

ASME CC N-755	FUSION PROCEDURE SPECIFICATION

title:

Prepared by:	Date:	Approved by:	Date:

MATERIAL:

FUSION DRAG PRESSURE:

FUSION MACHINE INFO:

FUSION PRESSURE:

BEAD - UP SIZE

DATA ACQ. MFGR:

DATA ACQ. ATTACHED:

HEATER REMOVAL TIME:

FUSION INTERFACIAL PRESSURE:

COOL TIME & FUSION PRESSURE:

HEATER SURFACE TEMPERATURE:

TECHNIQUE:

INFORMATION USE

Supplement 4 (Cont'd.)

Sheet 4 of 4

FORM QF-300

**FUSION MACHINE OPERATOR
PERFORMANCE QUALIFICATION (FPQ)
TEST FORM**

Operator's Name______________________ **Payroll No.**________ **Stamp I.D.**_______

Lab Test No.____________ **Test: Qualification** _______ **Requalification** ________
Fusion Machine Manufacturer ____
Fusion Machine Pipe Size Range ____
Test Position ____
Material Specification _________ **to** _________
Fusion Specification Procedure ______________________
Pipe Size ____________ **Pipe DR** ______________

NDE Requirements: Visual _________________ **Visual Results** _________________
Free Bend Test ______________ Bend Tests Results ______________
Data Acquisition Record Review Results _______________________________

Test Conducted By ____

We certify that the statements in this record are correct and that the fused joints are prepared, fused and tested in accordance with the requirements of Supplement 9, of AmerenUE 10CFR50.55a Request Number I3R-10.

Date ____________________ **Signed By** _______________________________________
Title

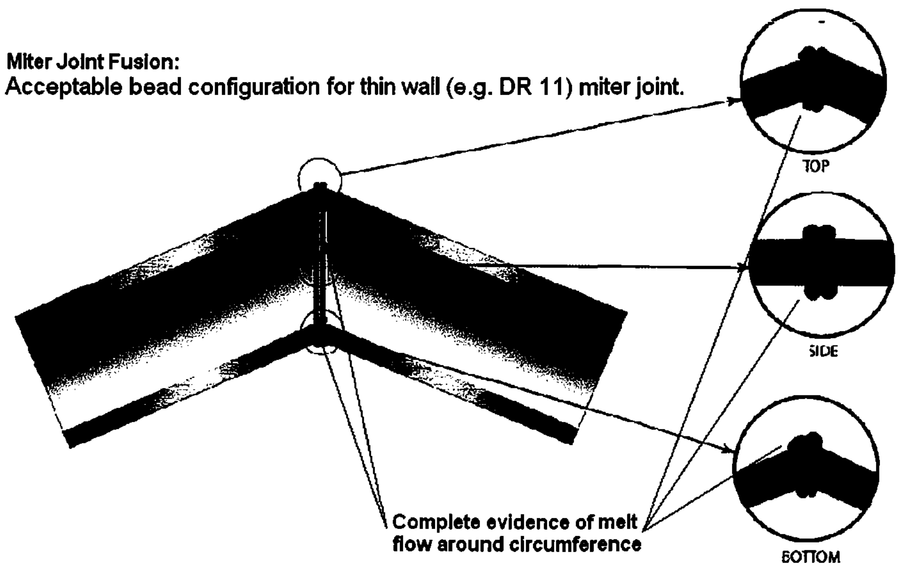
____

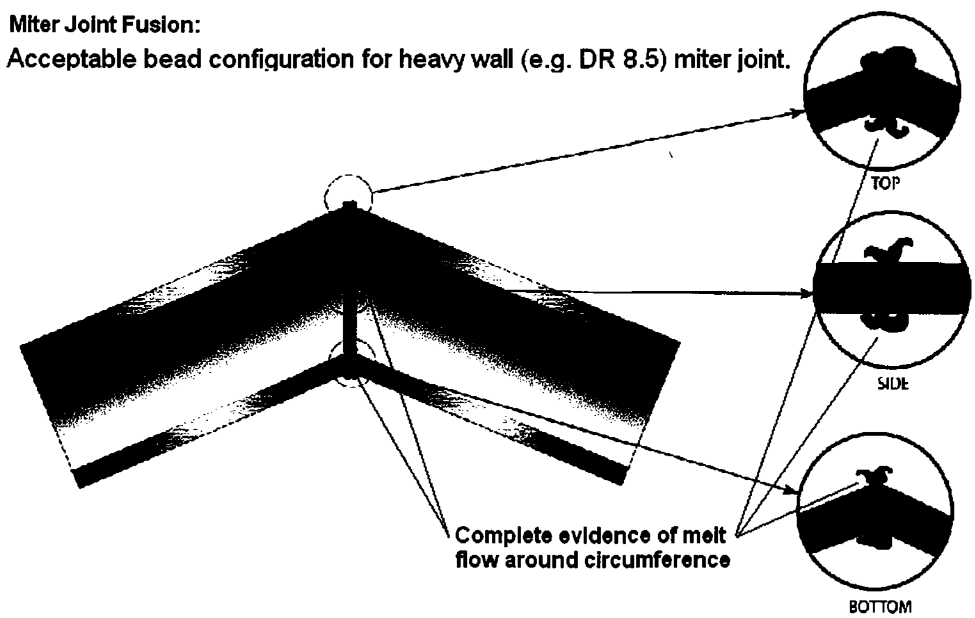
Supplement 5

Fusion Bead Configuration

Sheet 1 of 2

The following pages contain pictures of critical attributes of the completed thermal fusion butt joints. These pictures may be used by personnel performing a visual examination on fusion beads.



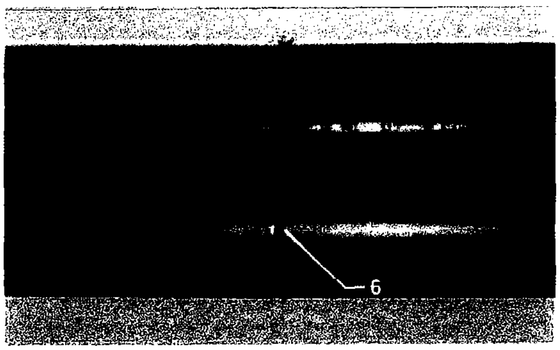


Supplement 5 (Cont'd.)

Sheet 2 of 2

Butt Fusion of Pipe

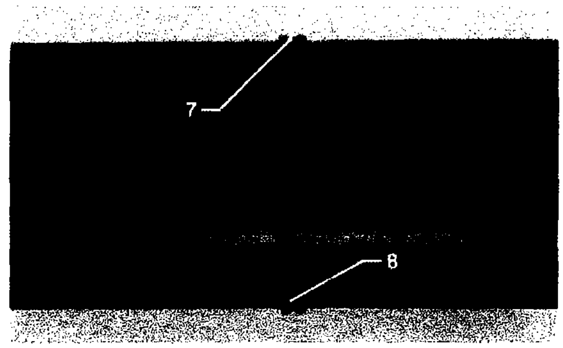
Unacceptable Appearance – Insufficient Melt



6. Melt Bead Too Small For 2-Inch And Larger Mains

Butt Fusion of Pipe

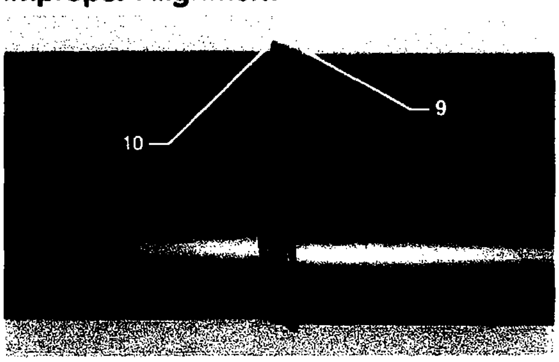
Unacceptable Appearance – Inadequate Roll Back



7. Insufficient Fusion Pressure – "V" Shaped Melt Appearance
8. Inadequate Roll Back of Bead

Butt Fusion of Pipe

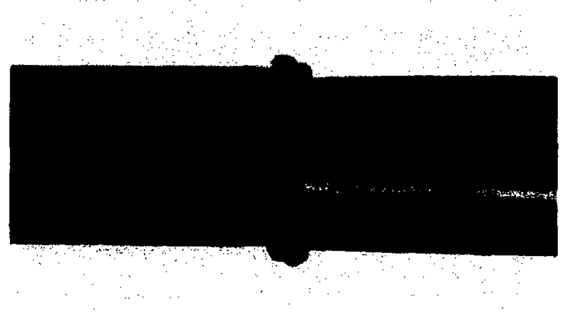
Unacceptable Appearance – Improper Alignment



9. "High-Low" Condition 10. Inadequate Roll Back Of Bead Due To Improper Alignment

Butt Fusion of Tubing

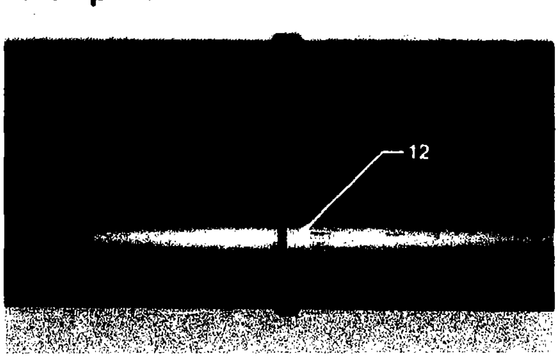
Unacceptable Appearance



11. Excessive Melt, Improper Alignment And/Or Excessive Pressure

Butt Fusion of Pipe

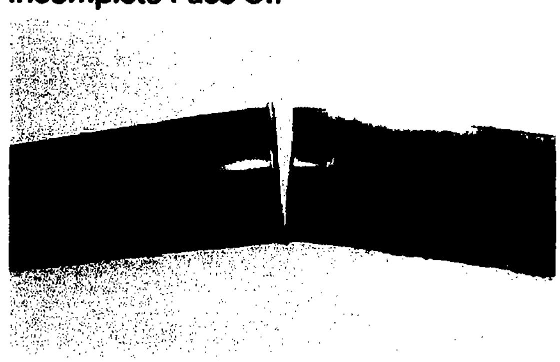
Unacceptable Appearance – Incomplete Face Off



12. No Melt Bead Caused By Incomplete Face Off

Butt Fusion of Pipe

Unacceptable Appearance – Incomplete Face Off



13. Unbonded Area In Joint Of Cut Strap

Supplement 9

High Density Polyethylene Pipe Fusing

Sheet 1 of 25

Supplement 9 (Cont'd.)

Sheet 2 of 25

Supplement 9 Article 1
Fusion General Requirements

QF-100 GENERAL

This Supplement relates to the qualification of fusion machine operators and the procedures that they employ in fusing high density polyethylene (HDPE) piping. Due to the major differences between metallic welding and plastic fusing, the Fusion Procedure Specification (FPS) and the Procedure Qualification Record (PQR) have been combined for this supplement.

QF-101 Scope

The requirements in this supplement apply to the preparation of the Fusion Procedure Specification (FPS), and the qualification of fusion machine operators for thermal butt fusion joining.

QF-102 Terms and Definitions

Some of the more common terms relating to fusion are defined in Supplement 1, and ASTM F412 Standard Terminology Relating to Plastic Piping Systems.

QF-103 Responsibility

QF-103.1 Fusion. AmerenUE is responsible for all fusing done for the project and shall conduct the tests required in this Supplement to qualify procedures (Article II), and the performance of fusion machine operators who use these procedures (Article III).

QF-103.2 Records. Records of the results obtained in the fusing procedure and fusion machine operator performance qualifications shall be maintained. These records shall be certified by AmerenUE and shall be accessible to the Authorized Nuclear Inspector.

QF-104 Documents

QF-104.1 A FPS is a written document that provides direction to the fusion machine operator for making fused joints in accordance with the requirements of this Supplement.

(a) The FPS specifies the conditions under which the fusing must be performed. These conditions include the HDPE materials that are permitted. Such conditions are referred to in this Supplement as fusing "essential variables." The FPS shall address these essential variables.

 INFORMATION USE

Supplement 9 (Cont'd.)

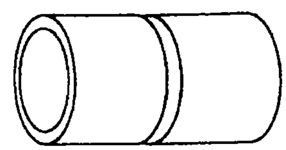
Sheet 3 of 25

(b) When required, qualification of a FPS is intended to determine that the fused joint proposed for construction is capable of providing the required properties for its intended application. FPS qualification establishes the properties of the fused joint, not the skill of the fusion machine operator.

QF-104.2 In performance qualification, the basic criterion established for fusion machine operator qualification is to determine the operator's ability to operate the fusing equipment to produce a sound fused joint.

QF-105 Joint Orientation

The orientation of all fused butt joints produced for tests or production shall be made with the horizontal axis position illustrated in Figure QF-105.



Horizontal Axis Position

Figure QF - 105

QF-106 Training

(a) Thermal Butt Joint - Each fusion machine operator will receive a minimum of 24 hours of training, covering the principles of the fusion process and the operation of the fusion equipment. There will be a two part test at the end of this training; Part 1 Theoretical Knowledge and Part 2 Performance Qualification.

(1) The theoretical test shall cover as a minimum; safety, fundamentals of the fusing process, and recognition of typical joint imperfections.

(2) Performance Qualification test using an approved FPS.

(b) Appendix A to this supplement provides guidance for a training program.

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QF-120 EXAMINATIONS

QF-121 Visual Examination. All fused joints shall receive a visual examination. The examination shall include all accessible surfaces of the fused joint and shall meet the following criteria;

(a) Joints shall exhibit proper fusion bead configuration, see Supplement 5.

(b) There shall be no evidence of cracks or incomplete fusion.

(c) Except for mitered joints, joints shall not be visually mitered (angled, off-set). The ovality offset shall be less than 10% of the minimum wall thickness of the fused components.

(d) The cleavage between fusion beads shall not extend to or below the outside diameter pipe surface (see Figure QF–121-1).

(e) For mitered joints, the beads may flare out instead of roll back to the pipe surface, and/or may exhibit multiple beads or heavy beads with no cleavage. In either case, there must be evidence of melt flow around the complete interior and exterior circumference of the joint. Refer to Supplement 5.

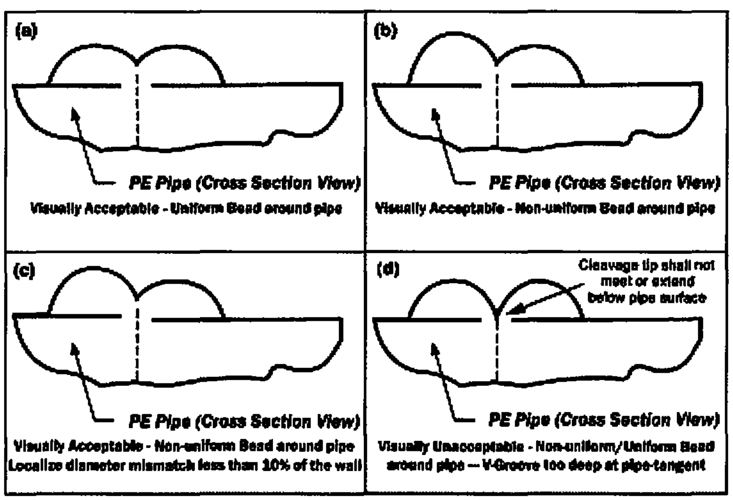

FIGURE QF-121-1

(f) Review the data acquisition record for the joint and compare it to the Fusion Procedure Specification (FPS) to ensure the proper parameters and procedures were followed in making the fused joint, see paragraph QF-122.

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QF-122 Data Acquisition Record Evaluation

QF-122.1 Data Acquisition Device

(a) The data recording device must be capable of recording the following butt fusion essential variables on each joint:

1) Heater Surface temperature
2) Interfacial Pressure
3) Gauge Pressure during the heat cycle
4) Gauge Pressure during the fusion/cool cycle
5) Time during the heat cycle
6) Time during the fusion/cool cycle
7) Heater removal time

(b) All job information related to the joints such as job number, joint number, employee number, time, date, fusion machine identification, pipe manufacturer and pipe material.

(c) The data recording device must be capable of storing at least (1) day of butt fusion joint information and capable of downloading this information as a permanent record.

QF-122.2 Data Acquisition Log Evaluation

The butt fusion joint record should be compared to the FPS to ensure that the proper butt fusion parameters and procedures were followed. If they were not, the joint should be cut and re-fused using the correct parameters and procedures per the FPS.

(a) Verify that all job related data was entered in the record.

(b) Verify that the recorded "Fuse" interfacial pressure was within the range of qualification.

(c) Verify that the heater surface temperature recorded was within the range of qualification.

(d) Verify that the Drag Pressure was recorded.

(e) The examiner must calculate the fusion pressure for the fusion machine and add the drag pressure to confirm the machine's hydraulic fusion gauge pressure. This fusion gauge pressure must be shown in the recorded pressure/time diagram at the initial heater contact and during the fusion/cool cycle.

(f) Verify that the fusion gauge pressure dropped quickly to a value less than or equal to the drag pressure at the beginning of the heat soak cycle.

Supplement 9 (Cont'd.)

(g) At the end of the heat soak cycle, review that the machine was opened, the heater removed and the pipe ends brought together at the fusion gauge pressure as quickly as possible (not to exceed allowance in procedure).

(h) Verify that the machine fusion gauge pressure was within the range of qualification for the pipe diameter being fused. Observe that the data recording device stopped logging at the end of the fusion / cool cycle.

QF-130 Tests

QF-131 High Speed Tensile Impact Test

QF-131.1 Significance and Use

This test method is designed to impart tensile impact energy to a butt fused plastic pipe specimen. The failure mode (brittle or ductile) are used as criteria in the evaluation of the butt fusion joint.

QF-131.2 Test Specimens

(a) The test specimen shall conform to the dimensions shown in Figure QF-131.2. Test specimens of butt fused pipe shall have the bead remain on the outside and inside. Test specimens of butt fused pipe shall use the full wall thickness.

(b) Preparation—Test specimens shall be prepared by machining operations on butt fused sections of pipe and on the pipe itself. The machining operations shall result in a smooth surface on both sides of the reduced area with no notches or gouges.

(c) All surfaces of the specimen shall be free of visible flaws, scratches, or imperfections. Marks left by coarse machining operations shall be carefully removed with a fine file or abrasive, and the filed surfaces shall then be smoothed with abrasive paper (600 grit or finer). The finishing sanding strokes shall be made in a direction parallel to the longitudinal axis of the test specimen. In machining a specimen, undercuts that would exceed the dimensional tolerances shall be avoided.

(d) When marking the specimens, use a permanent marker of a color that will be easily read or etch the specimen number in the area outside the hole.

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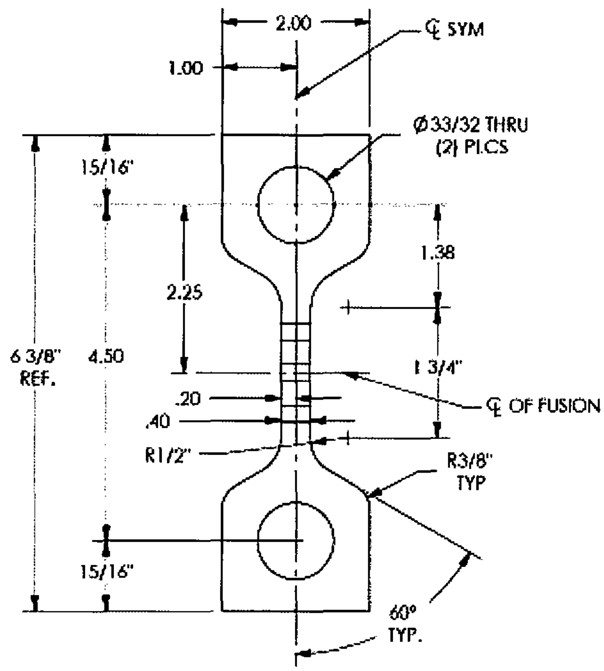

NOTES:

1. ALL MACHINED SURFACES 125 RMS OR BETTER

Tensile Full Thickness Impact Test Coupon Configuration

Figure QF-131.2

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QF-131.3 Number of Test Specimens

Test at least four specimens from butt fused pipe sections 90° apart for pipe sizes 4" and larger. Test two specimens from butt fused pipe sections 180° apart for pipe sizes 2" to 4".

QF-131.4 Speed of Testing The speed of testing shall be in accordance with Table QF-131.4.

Wall Thickness	Testing Speed
≤1.25 in. (32 mm)	6 in. /s (152 mm/s)
>1.25 in. (32 mm)	4 in. /s (102 mm/s)

Testing Speed Tolerance: +5 in./s to -1 in./s (+12.7 mm/s to -25.4 mm/s)

TABLE QF-131.4

QF-131.5 Conditioning

(a) Conditioning—Condition the test specimens at 73.4 ± 4°F [23 ± 2°C] for not less than 1 hour prior to test.

(b) Test Conditions—Conduct the tests at 73.4 ± 4°F [23 ± 2°C] unless otherwise specified by contract or the relevant ASTM material specification.

QF-131.6 Test Procedure

(a) Set up the machine and set the speed of testing to the proper rate as required in QF-131.4.

(b) Pin each specimen in the clevis tooling of the testing machine. This will align the long axis of the specimen and the tooling with the direction of pull of the machine.

(c) Determine the mode of failure and note in the report.

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QF-131.7 Acceptance Criteria

Failure mode shall be ductile. Reference Figure QF-130.7.

Figure A
Brittle Failure

Figure B
Ductile Failure
Outside Fusion Interface

Figure C
Ductile Failure
Adjacent to Fusion Interface

NOTE: ◄—— Denotes Fusion Bead

FIGURE QF-130.7 Tensile Test Sample Evaluation Sample

QF-132 Elevated Temperature Sustained Pressure Tests

QF-132.1 Specimens

Butt fuse (2) pieces of 8" IPS DR 11 PE 3408/PE 4710 pipe x 40" long using the FPS outlined in this Supplement and perform the elevated temperature sustained pressure tests specified in ASTM D-3055-03a.

QF-133 FREE BEND TESTS

QF-133.1 Specimens

Two bend specimens as shown in Figure 133.1 shall be removed from the joint approximately 180° apart. For qualification coupons greater than 1" thick, alternative means of bend testing may be used provided similar cross-sectional stress is obtained at the joint.

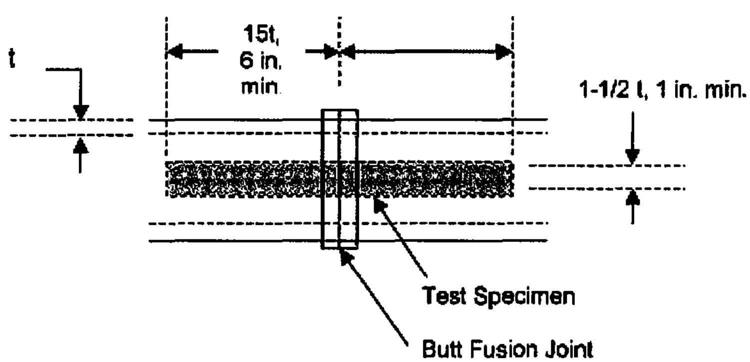

FIGURE QF-133.1

 INFORMATION USE

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QF-133.2 Testing Procedure

One test specimen shall be bent so that the inside surface of the joint is in tension and the other shall be bent so that the outside surface of the joint is in tension. The ends of each specimen shall be brought together until the ends of the specimens touch.

QF-133.3 Acceptance Criteria

The specimens shall not crack or fracture.

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SUPPLEMENT 9 ARTICLE 2
Fusion Procedure Qualifications

QF-200 GENERAL

QF-201 Written Fusion Procedure Specifications shall be Prepared as Follows:

(a) Fusion Procedure Specification (FPS). A FPS is a written qualified fusing procedure prepared to provide direction for making production fused. The FPS shall be used to provide direction to the fusion machine.

(b) Contents of the FPS. The completed FPS shall describe all of the essential variables for each fusion process used in the FPS. These essential variables are listed and defined in QF-220. Any other information may be included in the FPS that may be helpful in making a fused joint.

(c) Changes in essential variables require requalification of the FPS.

(d) Format of the FPS. The information required to be in the FPS may be in any format, written or tabular, as long as every essential variables outlined in QF-220 is included or referenced. Form QF-200 has been provided as a guide for the FPS. This Form includes the required data for the fusing, it is only a guide and is located in Supplement 4.

(e) Availability of the FPS. A FPS used for production fusing shall be available for reference and review by the Authorized Nuclear Inspector at the fabrication or installation site.

QF-210 Responsibility

(a) The parameters applicable to fusing that are performed in construction of fusion joints shall be listed in a document known as a Fusion Procedure Specification (FPS).

(b) The FPS shall be qualified by the fusing of test coupons, testing of specimens cut from the test coupons, and recording fusing data and test results in the FPS. The fusion machine operators used to produce the fused joints to be tested for qualification of procedures shall be under the full supervision and control of AmerenUE during the production of these test fused joints. The fused joints to be tested for qualification of procedures shall be fused either by direct employees or by individuals engaged by contract for their services as fusion machine operators under the full supervision and control of AmerenUE. It is not permissible to have the supervision and control of fusing of the test fused joints performed by another organization. It is permissible, however to subcontract any or all of the work of preparation of test material for fusing and subsequent work on preparation of test specimens from the completed fused joint, performance of nondestructive examination, and mechanical tests, provided AmerenUE accepts the responsibility for any such work.

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(c) AmerenUE has responsible operational control of the production of all fusion joints to be made for this project.

(d) AmerenUE shall certify each Fusion Procedure Specification.

QF-220 FUSION PROCEDURE SPECIFICATION (FPS)

QF-221 STANDARD FUSION PROCEDURE SPECIFICATION

(a) The Standard Fusion Procedure Specification is based on standard industry practice and testing as reported in the Plastics Pipe Institute (PPI), report TR-33/2001,

(a) (b) When the FPS is limited to the following parameters, qualification testing is not required. If there are to be deviation from the conditions listed below, procedure qualification testing in paragraph QF-223 shall be performed.

(1) The pipe material is PE3408 or PE4710.

(2) Position is limited to horizontal, ±45°.

(3) The pipe ends shall be faced to establish clean, parallel mating surfaces that for non-mitered joints are perpendicular to the pipe centerline on each pipe end. When the ends are brought together, there shall be no visible gap.

(4) The external surfaces of the pipe are aligned to within 10% of the pipe wall thickness.

(5) The drag pressure shall be measured and recorded. The fusion pressure shall be calculated so that an interfacial pressure of 60 to 90 psi is applied to the pipe ends.

(6) The heater plate surface temperature shall be 400 to 450°F measured at 4 locations approximately 90° apart on both sides of the heater plate.

(7) The heater plate shall be inserted into the gap between the pipe ends and fusion pressure shall be applied and maintained until an indication of melt is observed around the circumference of the pipe. The pressure shall be reduced to drag pressure and the fixture shall be locked in position so that no outside force is applied to the joint during the soak time.

(8) The ends shall be held in place until the following bead size is formed between the heater faces and the pipe ends, shown in Table QF-221(a)-1.

 INFORMATION USE

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Approximate Melt	
Pipe Size (Dia) Inches	**Bead Size Inches**
≤ 1 1/4	1/32 to 1/16
> 1 1/4 to < 3	1/16
≥ 3 to ≤ 8	1/8 to 3/16
> 8 to ≤ 12	3/16 to 1/4
> 12 to ≤ 24	1/4 to 7/16
> 24 to ≤ 36	7/16 to 9/16
> 36 to ≤ 54	9/16 minimum

TABLE QF-221(a)-1

(9) After the proper bead size is formed, machine shall be opened and the heater removed. The pipe ends shall be brought together and the fusion pressure reapplied.

(10) The maximum time from removal of the heating plate until the pipe ends are pushed together shall not exceed the time given in Table QF-221(a)-2.

Pipe Wall Thickness (Inches)	Max. Heater Plate Removal Time
.20 to .36	8 sec.
> .36 to .55	10 sec.
> .55 to 1.18	15 sec.
>1.18 to 2.0	25 sec.
> 2.0 to 4.0	45 sec.
> 4.0 to 6.0	60 sec.
Shop Application	
>3.0 to 4.0	60 sec.
>4.0 to 6.0	75 sec.

TABLE QF-221(a)-2

(11) The pressure is maintained until the joint has cooled to the touch, after which the pipe may be removed from the joining machine. Handling of the pipe shall be minimized for an additional 30 minutes.

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QF-222 Essential Variables for Fusion Procedure Specifications (FPS)

Any change in the essential variables listed below and QF –221, requires requalification of the FPS per QF –223.

(a) Essential Variables

(1) The pipe material,

(2) Heater surface temperature range,

(3) Butt fusion interfacial pressure range,

(4) Deleted (redundant to 3)

(5) Heater bead up size,

(6) Heater removal time,

(7) Cool-down time under fusion pressure

QF-223 Testing Procedure to Qualify the FPS

(a) Use 8" IPS HDPE DR11 pipe sizes in qualification test joints.

(b) Make the following butt fusion joints using the following combinations of heater temperature ranges and interfacial pressure ranges and the FPS:

(1) High heater surface temperature and high interfacial pressure, (5) joints

(2) High heater surface temperature and low interfacial pressure, (5) joints

(3) Low heater surface temperature and high interfacial pressure, (5) joints

(4) Low heater surface temperature and low interfacial pressure, (5) joints

(c) Evaluate (3) joints of each combination using the High Speed Tensile Impact Tests per QF-131. All joints must fail in a ductile mode.

(d) Evaluate (2) joints of each combination using the Sustained Pressure Testing per QF-132. All joints must pass this test.

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QF-230 Mechanical Tests

QF-231 General Requirements

(a) The type and number of test specimens that shall be tested to qualify a butt FPS are given in QF-223, and shall be removed in a manner similar to that shown in QF-130. If any test specimen required by QF-223 fails to meet the applicable acceptance criteria, the test coupon shall be considered as failed.

(b) When it can be determined that the cause of failure is not related to fusing parameters, another test coupon may be fused using identical fusing parameters.

(c) Alternatively, if adequate material of the original test coupon exists, additional test specimens may be removed as close as practicable to the original specimen location to replace the failed test specimens.

(d) When it has been determined that the test failure was caused by an essential variable, a new test coupon may be fused with appropriate changes to the variable(s) that was determined to cause the test failure.

(e) When it is determined that the test failure was caused by one or more fusing conditions other than essential variables, a new set of test coupons may be fused with the appropriate changes to the fusing conditions that were determined to cause the test failure. If the new test passes, the fusing conditions that were determined to cause the previous test failure shall be addressed by the manufacturer to ensure that the required properties are achieved in the production fused joint.

QF-232 Preparation of Test Coupon

The base materials shall consist of pipe. The dimensions of the test coupon shall be sufficient to provide the required test specimens.

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SUPPLEMENT 9 ARTICLE 3
Fusion Performance Qualification

QF-300 GENERAL

QF-300.1 This Article lists the essential variables that apply to fusion machine operator performance qualifications.

The fusion machine operator qualification is limited by the essential variables.

QF-300.2

(a) The basic premises of responsibility in regard to fusion are contained within QF-103 and QF-301.2. AmerenUE shall be responsible for conducting tests to qualify the performance of fusion machine operators in accordance with qualified Fusion Procedure Specifications, which are employed in the construction of fused joints built in accordance with this Supplement. This responsibility cannot be delegated to another organization.

(b) The fusion machine operators used to produce such fused joints shall be tested under the full supervision and control of AmerenUE during the production of these test fused joints. It is not permissible to have the fusing performed by another organization. It is permissible, however, to subcontract any or all of the work of preparation of test materials for fusing and subsequent work on the preparation of test specimens from the completed fused joints, performance of nondestructive examination and mechanical tests, provided AmerenUE accepts full responsibility for any such work.

(c) AmerenUE is the organization which has responsible operational control of the production of the fused joints to be made in accordance with this Supplement.

QF-301 Tests

QF-301.1 Intent of Tests. The performance qualification tests are intended to determine the ability of fusion machine operators to make sound fused joints.

QF-301.2 Qualification Tests. AmerenUE shall qualify each fusion machine operator for the fusing process to be used in production. The performance qualification test shall be fused in accordance with a qualified Fusion Procedure Specifications (FPS). Changes beyond which requalification is required are given in QF-322. Allowable visual and mechanical examination requirements are described in QF-303. Retests and renewal of qualification are given in QF-320.

The fusion machine operator who prepares the FPS qualification test coupons meeting the requirements of QF-200 is also qualified within the limits of the performance qualifications, listed in QF-303 for fusion machine operators.

Supplement 9 (Cont'd.)

The performance test may be terminated at any stage of the testing procedure, whenever it becomes apparent to the supervisor conducting the tests that the fusion machine operator does not have the required skill to produce satisfactory results.

QF-301.3 Identification of Fusion machine operators. Each qualified fusion machine operator shall be assigned an identifying number, letter, or symbol which shall be used to identify the work of that fusion machine operator.

QF-301.4 Record of Tests. The record of Fusion machine operator Performance Qualification (FPQ) tests shall include the essential variables, the type of test and test results, and the ranges qualified in accordance with Form QF-300 for each fusion machine operator.

QF-302 Type of Test Required

QF-302.1 Mechanical Tests. All mechanical tests shall meet the requirements prescribed in QF-133.

QF-302.2 Test Coupons in Pipe. For test coupons made on pipe in the horizontal axis position of Figure QF-105. The coupons shall be removed from the test piece in accordance with Figure QF-133.1.

QF-302.3 Visual Examination. For pipe coupons all surfaces shall be examined visually per QF-121 before cutting of bend specimens. Pipe coupons shall be visually examined per QF-121 over the entire circumference, inside and outside.

QF-303 Fusion Machine Operators

Each fusion machine operator who fuses under the rules of this Supplement shall have passed the mechanical and visual examinations prescribed in QF-302.1 and QF-302.3 respectively.

QF-303.1 Examination. Fused joints made in test coupons for performance qualification shall be examined by mechanical and visual examinations (QF-302.1, QF-302.3).

Supplement 9 (Cont'd.)

QF-310 QUALIFICATION TEST COUPONS

QF-310.1 Test Coupons. The test coupons shall be pipe. Qualifications for pipe are accomplished by fusing one pipe assembly in the horizontal axis position (figure QF-105). The minimum pipe size shall be IPS 6.

QF-320 RETESTS AND RENEWAL OF QUALIFICATION

QF-321 Retests

A fusion machine operator who fails one or more of the tests prescribed in QF-303, as applicable, may be retested under the following conditions.

QF-321.1 Immediate Retest Using Visual Examination. When the qualification coupon has failed the visual examination of QF-302.3, retesting shall be by visual examination before conducting the mechanical testing.

When an immediate retest is made, the fusion machine operator shall make two consecutive test coupons all of which shall pass the visual examination requirements.

The examiner may select one of the successful test coupons from each set of retest coupons which pass the visual examination for conducting the mechanical testing.

QF-321.2 Immediate Retest Using Mechanical Testing

When the qualification coupon has failed the mechanical testing of QF-302.1, the retesting shall be mechanical testing.

When an immediate retest is made, the fusion machine operator shall make two consecutive test coupons which shall pass the test requirements.

QF-321.4 Further Training. When the fusion machine operator has had further training or practice, a new test shall be made.

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QF-322 Expiration and Renewal of Qualification

QF-322.1 Expiration of Qualification. The performance qualification of a fusion machine operator shall be affected when one of the following conditions occurs:

(a) When he has not performed thermal butt fusion during a period of 6 months or more, his qualification shall expire.

(b) When there is a specific reason to question his ability to make fused joints that meet the specification, the qualifications that support the fusing he is doing shall be revoked.

QF-322.2 Renewal of Qualification

(a) Renewal of qualification expired under QF-322.1(a) may be made by fusing a single test coupon and by testing of that coupon as required by QF-301. A successful test renews the fusion machine operator previous qualifications for the process for which he was previously qualified.

(b) Fusion machine operators whose qualifications have been revoked under QF-322.1(b) above shall requalify. Qualification shall utilize a test coupon appropriate to the planned production work. The coupon shall be fused and tested as required by QF-301 and QF-302. Successful test restores the qualification.

QF-330 FUSION ESSENTIAL VARIABLES FOR FUSION MACHINE OPERATORS

QF-331 General

A fusion machine operator shall be requalified whenever a change is made in one or more of the essential variables listed.

(a) A change in pipe diameter from one range to another;

(1) Less than IPS 8,

(2) IPS 8 to IPS 24, and

(3) IPS over 24.

(b) A change in name of the manufacturer of equipment.

(c) The axis of the pipe is limited beyond the horizontal position ± 45°. Qualification in any position other than horizontal qualifies the orientation tested ± 20°.

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QF-340 Testing

(a) Test joints shall be 6” IPS minimum. A data acquisition device shall be attached to the fusion machine and the data concerning the joint entered. The data acquisition device shall be used to record data required by QF-122.

(b) The supervisor conducting the test shall observe making of the butt fusion joint and note if the fusion procedure (FPS) was followed.

(c) The completed joint shall be visually examined and meet the acceptance criteria of QF-121.

(d) After the joint is complete, the data acquisition record shall be reviewed by the assessor and compared to the FPS to ensure the proper procedures were followed.

(e) Bend test specimens shall be removed, tested and meet the acceptance criteria in accordance with QF-133.

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Non-Mandatory
Supplement 9 Appendix A
Fusion Machine Operator Qualification Training

A-1000 SCOPE

(a) The major portion of the quality of HDPE piping systems is determined by the skills of the fusion machine operators. When installing polyethylene (PE) piping, the quality of the fusion joints is essential for the piping system.

(b) It is important that the fusion machine operators are trained and competent in the fusion technology employed in constructing HDPE piping systems. Continued competence of the fusion operator is covered by periodic re-training and re-assessment.

(c) This document gives guidance for the training, assessment and approval of fusion operators in order to establish and maintain competency in construction of high density polyethylene piping systems for pressure applications. The fusion joining technique covered by this Appendix is butt fusion. This article covers both the theoretical and practical knowledge necessary to ensure high quality fusion joints.

A-1100 REFERENCES

(a) Plastics Pipe Institute (PPI) Technical Report TR-33/2001 "Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe

(b) American Society of Testing and Materials (ASTM) D 2657-03 "Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings"

(c) ISO TR 19480/2005 "Thermoplastics pipes and fittings for the supply of gaseous fuels or water – Guidance for training and assessment of fusion operators"

A-2000 TRAINING

A-2100 Training Course

(a) A trainee fusion operator for HDPE systems should follow a training course in order to obtain a fusion operator certificate for HDPE pipes. The course should cover all aspects of the butt fusion process including safety, machine evaluation and maintenance, machine operation, FPS guidelines, pressure and temperature setting, data log device operation and set-up, in-ditch fusion techniques, visual examination guidance, and data log record evaluation. The minimum course duration is 24 hours.

(b) The course will be delivered by a competent qualified trainer with a minimum of 3 years of experience in the butt fusion processes and who has mastered the techniques involved.

Supplement 9 (Cont'd.)

(c) The trainer should have a range of fusion machines representative of the equipment encountered on worksites for installing pipes, in order for the trainee fusion operator to become acquainted with the fusion equipment commonly used. The trainee fusion operator may be trained on one of these fusion machines or on a machine from his own company if accepted by the training center. The fusion equipment must comply with the fusion machine manufacturer's specifications and/or ISO 12176-1 "Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 1: Butt fusion".

A-2200 Operator Assessment

The trainee fusion operator who has followed a training course as described above should then pass a theoretical and practical assessment in order to be qualified as a fusion operator for PE systems. The assessor should not be the trainer but should have the same assessment qualifications as the trainer shown above.

A-2300 Training Curriculum

(a) The training course should comprise of any combination of fusion packages based on the requirements of utility or pipeline operators. These packages may be given as individual modules or combined to suit requirements. The course shall include safety training related to the fusion process and equipment.

(b) All consumables and tools necessary for the training package should be available during the training session. The pipes and fittings to be used shall conform to the ASTM product forms permitted by this Supplement.

(c) The lessons should be designed so that the trainee fusion operator learns to master the fusion technique and attains a good working knowledge of the piping system materials and practical problems encountered when fusing pipe in the field. The fusion operator should receive a written manual covering all the elements dealt with in the training.

Supplement 9 (Cont'd.)

(d) The theoretical course should deal with general information in connection with raw materials, pipes and fittings, and also with theoretical knowledge about preparation, tools, and devices, joining components, different materials, different diameter ratios and correct and incorrect parameters. The safety course should include information concerning the fusion process, such as protective clothing, general safety, regulations for electrical equipment, handling heater plates, etc. Areas of study should include but not be limited to the following:

(1) Butt fusion joining

- Principles of fusion
- Straight/coiled pipes, service lines, main lines, etc.
- Components: pipes, flange adapters saddle fittings, other fittings
- Butt fusion equipment: manual, semi-automatic and automatic machines.
- Joint preparation: Cleaning, rounding, alignment, facing, etc
- Butt fusion cycle: pressure, time and temperature relationships, diagram.
- Failure modes: understanding and avoiding possible errors
- Test methods: visual examination, high speed tensile-impact test, bending test, hydrostatic test, data log recording / evaluation, etc.

(2) The trainee fusion operator should be familiar with the butt fusion joining technique and procedure (FPS) by making a sufficient number of butt fusion joints. In some cases, the fusion technique may vary slightly according to diameter, material or other factors. In such cases, the trainee fusion operator should also be made familiar with the various techniques.

(3) The trainee should start by making a butt joint between two pipes, and should then learn to make butt fusion joints with pipes and fittings such as tees, reducers, etc.

(4) The trainee should learn how to detect and avoid typical fusion defects.

(5) The trainee should learn how to assess the quality of a butt fusion joint by doing a visual examination of the butt fusion joint and comparing it to the visual guidelines published in the pipe manufacturer's heat fusion joining procedure booklet. The trainee should also compare the data log record to the FPS to ensure the proper parameters and procedures were followed in the butt fusion process.

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A-3000 ASSESSMENT AND TESTING

(a) Training program should end with a theoretical and practical examination (test piece).

(b) The content of the theoretical examination shall consist of not less than (20) multiple choice questions about the butt fusion process, fusion machine operation, pipe, quality examination, safety, etc. within a set period of time. A score of 80% or better is considered passing on this examination. Questions to be included but not limited to are:

How do you calculate the fusion machine gauge pressure?
What is the proper heater surface temperature range from the FPS?
What is the proper butt fusion interfacial pressure range from the FPS?
How do you calculate the drag pressure?
How do you know when to remove the heater in the heating cycle?
How long do you leave the pipe ends together under pressure in the cooling cycle?
What is the difference between IPS pipe and DIPS pipe?
How do I determine the hydraulic fusion machines total effective piston area?
How is the total effective piston area of the fusion machine used to determine the fusion machines gauge pressure for a specific pipe?
How do you adjust the machine to improve the alignment of the pipe after facing?
How much material should be removed from the pipe ends in the facing operation?
How do you determine if the fusion machine conforms to the equipment manufacturer's specifications?
How do you align the pipe in the butt fusion machine?
Can you butt fuse pipe in a ditch?
What is interfacial pressure?

(c) The practical examination will require the trainee fusion operator to make a fusion joint with a hydraulic butt fusion machine with a minimum pipe size of 6" IPS DR11. A data acquisition device must be attached to the fusion machine and the data concerning the joint entered. The data log device shall be used to record the joint made by the trainee. The assessor shall observe the butt fusion joint and note if the proper procedure (FPS) was followed. After the joint is complete, the data log record shall be reviewed by the assessor and compared to the FPS to ensure the proper procedures was followed. The assessor will then conduct a visual examination of the joint to make sure it satisfies the pipe manufacturers recommend visual guidance criteria per QF-121 of this Supplement.

(d) If a data log device is not available, the assessor will manually record the butt fusion parameters used in the butt fusion process. This should be compared with the FPS to ensure they agree.

(e) Trainee fusion operators who pass the theoretical and practical examination would receive a fusion operator certificate bearing the logo of the assessment center awarding the approval. The fusion operator certificate should state the technique or techniques and fusion machines for which the operator is qualified.

Supplement 9 (Cont'd.)

A-4000 REASSESSMENT

If the trainee fails one of the examinations, he should retake it after a period not shorter than one week. If the trainee fails the examination for the second time, the trainee should repeat the training course before taking the test again.

ATTACHMENT 3

NRC SAFETY EVALUATION FOR RELIEF REQUEST I3R-10

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 31, 2008

Mr. Adam C. Heflin
Senior Vice President and
Chief Nuclear Officer
Union Electric Company
P.O. Box 620
Fulton, MO 65251

SUBJECT: CALLAWAY PLANT, UNIT 1 – RELIEF REQUEST I3R-10 FOR THIRD 10-YEAR INSERVICE INSPECTION INTERVAL - USE OF POLYETHYLENE PIPE IN LIEU OF CARBON STEEL PIPE IN BURIED ESSENTIAL SERVICE WATER PIPING SYSTEM (TAC NO. MD6792)

Dear Mr. Heflin:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed and evaluated the information provided by Union Electric Company (the licensee), in its letter dated August 30, 2007, as supplemented by letters dated April 17, July 10, July 24, September 15, and October 9, 2008. The licensee requested approval of Relief Request I3R-10 under Title 10 of the *Code of Federal Regulations*, (10 CFR) Section 50.55a for use of high-density polyethylene (HDPE) pipe in lieu of carbon steel pipe in buried essential service water (ESW) piping system.

The licensee proposed an alternative to certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) at the Callaway Plant, Unit 1 (Callaway) for its third 10-year inservice inspection (ISI) interval, which is scheduled to end on December 18, 2014. Specifically, the licensee proposed using HDPE in lieu of the required ASME Code, Section XI, Class 3 metal piping for buried portions of the ESW system. On September 19, 2008, the NRC staff conducted a phone call with the licensee. During that phone call, the NRC staff asked the licensee to provide its calculation for thermal gradient stress analysis. In the October 9, 2008 response, the licensee provided its calculation addressing the thermal gradient stresses. The NRC staff determined the results of the calculation are acceptable. In the October 9, 2008 response, the licensee's calculation was based on a design factor (DF) of 0.5, and another calculation was based on a DF of 0.56, which had a notation "for information only." The NRC staff does not accept the use of DF of 0.56. Therefore, the NRC staff's evaluation of the relief request is based only on results corresponding to a DF of 0.50.

Based on the proposed alternative and information provided by the licensee, the NRC staff has determined that the use of HDPE pipe for the buried section of the ESW system, as described in Relief Request I3R-10, will provide an acceptable level of quality and safety. Pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of HDPE pipe for the buried section of the ESW system for Callaway's third 10-year ISI interval, scheduled to end on December 18, 2014.

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

The NRC staff's safety evaluation is enclosed.

Sincerely,

Michael T. Markley

Michael T. Markley, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure:
Safety Evaluation

cc w/encl: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST NO. I3R-10

THIRD 10-YEAR INSERVICE INSPECTION INTERVAL

UNION ELECTRIC COMPANY

CALLAWAY PLANT, UNIT 1

DOCKET NO. 50-483

1.0 INTRODUCTION

By letter dated August 30, 2007, as supplemented by letters dated April 17, July 10, July 24, September 15, and October 9, 2008 (Agencywide Document Access and Management System (ADAMS) Accession Nos. ML072550488, ML081190648, ML082470210, and ML082140282, ML082630806, and ML082900027, respectively), Union Electric Company (the licensee) requested U.S. Nuclear Regulatory Commission (NRC) approval of Relief Request (RR) I3R-10 for Callaway Plant, Unit 1 (Callaway). The request for relief is associated with American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Class 3 safety-related buried piping applications pertaining to the essential service water (ESW) system of Callaway. The licensee requested NRC approval to allow the replacement of the existing carbon steel piping with high-density polyethylene (HDPE) material, as an alternative to ASME Code, Section XI requirements under paragraph 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations* (10 CFR). The RR I3R-10 proposed to replace the following ESW trains A and B carbon steel piping:

- 30-inch diameter supply lines from pump house to control building with 36-inch diameter HDPE piping;
- 30-inch diameter return lines from control building to cooling tower with 36-inch diameter HDPE piping; and
- 4-inch diameter strainer backwash lines with 4-inch diameter HDPE piping.

The alternative proposed in the RR I3R-10 is for the third 10-year inservice inspection (ISI) interval for Callaway, which is currently scheduled to end on December 18, 2014.

2.0 REGULATORY REQUIREMENTS

In accordance with 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components must meet the requirements set forth in ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plants Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that all inservice

Enclosure

examinations and system pressure tests conducted during the first 10-year interval, and subsequent intervals, comply with the requirements in the latest edition and addenda of ASME Code, Section XI, incorporated by reference in 10 CFR 50.55a(b) on the date 12 months prior to the start of the 10-year interval. For Callaway, the Code of record for the third 10-year ISI interval is the 1998 Edition through 2000 Addenda of Section XI of the ASME Code.

Alternatives to requirements may be authorized or relief granted by the NRC pursuant to 10 CFR 50.55a(a)(3)(i), 10 CFR 50.55a(a)(3)(ii), or 10 CFR 50.55a(g)(6)(i). In proposing alternatives or requesting relief, the licensee must demonstrate that: the proposed alternatives provide an acceptable level or safety; compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety; or conformance is impractical for the facility. Pursuant to 10 CFR 50.55a(g)(4)(iv), ISI items may meet the requirements set forth in subsequent editions and addenda of the ASME Code that are incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed therein, and subject to Commission approval. Portions of editions and addenda may be used provided that related requirements of the respective editions and addenda are met.

3.0 TECHNICAL EVALUATION

3.1 Affected Components

ASME Code Class 3 buried ESW piping. The proposed alternative is 36-inch nominal outside diameter, Dimension Ration (DR) 9.5, and 4-inch nominal outside diameter, DR 9.0, HDPE piping.

3.2 Applicable Code Requirements

ASME Code, Section XI, IWA-4221(b) requires that "[a]n item to be used for repair/replacement activities shall meet the Construction Code specified in accordance with (1), (2), and (3)," and ASME Section XI, IWA-4221(b)(1) requires that "[w]hen replacing an existing item, the new item shall meet the Construction Code to which the original item was constructed."

The Construction Code of record for the ASME Code, Section XI, Class 3 ESW piping is ASME, Section III, Division 1, Subsection ND, 1974 Edition through Summer 1975 Addenda.

3.3 Proposed Alternative

The licensee requests to use Reference 7.1 titled, "Requirements for HDPE Piping for Nuclear Service," dated July 10, 2008, as supplemented in the licensee's responses to NRC's request for additional information, for material, design, fabrication, installation, examination, and testing of HDPE pipe for ASME Section III, Division 1, Class 3 buried piping.

3.4 Licensee Proposed Alternative and Basis for Use

The Callaway ESW system was originally designed with unlined carbon steel piping. Plant-specific and industry operating experience has shown that carbon steel piping is susceptible to fouling, corrosion, and microbiologically induced corrosion (MIC) for raw water applications.

The use of corrosion-resistant steel piping provides added resistance to such conditions, but does not eliminate susceptibility. Alternatively, the use of internal linings or coatings in carbon steel piping provides resistance to such conditions. However, degradation of and/or damage to the linings and coatings can cause exposure of the carbon steel piping to the raw water, resulting in piping degradation. Additionally, the linings and coatings can pose a potential foreign material concern, if they are released from the piping wall as a result of the degradation or damage.

HDPE piping will not rust, rot, corrode, tuberculate, or support biological growth. The use of HDPE piping in raw water applications will thus ensure long-term structural integrity and water flow reliability. Callaway has recently installed approximately 600 linear feet of 36-inch diameter buried HDPE piping in a non-safety-related blowdown application and has not experienced any significant problems. On a larger scale, Duke Power Company (DPC) has installed 20,000 linear feet of HDPE piping at Catawba Nuclear Station in non-safety-related raw water applications. Since the installations began in 1998, the DPC has reported that the material has had an excellent service history and has not experienced fouling or corrosion.

The Construction Code and later editions and addenda of this Construction Code do not provide rules for the material, design, fabrication, installation, examination, and testing of piping constructed with HDPE material. The licensee has requested to be allowed the replacement of buried carbon steel piping in the Callaway ESW system with HDPE piping. The replacement will be in accordance with the requirements for HDPE piping as outlined in Attachment 5 of Reference 7.1.

Engineering calculations and analytical evaluations were performed by the licensee utilizing the requirements and design rules described in Reference 7.1 of Callaway's RR I3R-10. Polyethylene piping is qualified for identical loading conditions (e.g. pressure, temperature, seismic) using similar design criteria as the original steel piping. Based on its evaluations for using polyethylene piping material in the proposed 36-inch supply line, 36-inch return line, and 4-inch strainer backwash lines of the ESW system, the licensee concluded that the use of polyethylene piping will result in improved system performance and enhanced system reliability, and the proposed alternative will provide an acceptable level of quality and safety. It was also mentioned by the licensee that the resistance of polyethylene pipe to corrosion and fouling and MIC ensures long-term reliability of the risk-significant ESW system.

Pursuant to 10 CFR 50.55a(a)(3)(i), in lieu of the requirement of Section XI, IWA-4221(b)(1) for replacement of the ESW system piping, this alternative to the original Construction Code provides an acceptable level of quality and safety for repair and replacement activities for ASME Class 3 buried piping.

4.0 STAFF EVALUATION

The staff evaluation was based on assessment of the following aspects:

- Qualification, testing, examination, and some aspects of quality control, and

  Structural integrity and design evaluation

4.1 Qualification, testing, examination, and some aspects of quality control

The ASME Code, Sections III and XI predominately address application for metal piping, vessels, and components. The metal piping commonly used to hold and transport raw or service water in nuclear power plants is susceptible to corrosion, fouling, rusting, and MIC attacks. To mitigate these degradation mechanisms, a few nuclear power plants have selectively installed HDPE piping in non-safety related applications. To date, the HDPE piping applications have been free of these degradation mechanisms. The industry's experience indicates that selected ASME Code Class 3 water carrying systems would be suitable for HDPE piping as an alternative to the current metal piping.

The licensee is relying on the process described in Reference 7.1, in-house destructive and nondestructive testing, data published by the Plastic Pipe Institute (PPI), "Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, TR-33/2001," PPI, "Handbook of Polyethylene Pipe," and Reference 7.1. The licensee is butt fusing HDPE pipe joints autogenously using performance-based qualified procedures, equipment, and personnel. A portion of the ESW system is buried with access locations available for future ISI, if needed. The fusing process reviewed by the NRC staff covered qualifications, testing, examinations, and some aspects of quality control.

Although parts of the submittal referenced ASME Code Case N-755, "Use of Polyethylene PE Plastic Pipe Section III, Division 1 and Section XI," the NRC staff has based its conclusions on the engineering information provided by the licensee. Code Case N-755 is addressed in section 4.2.1 of this safety evaluation.

4.1.1 Fusion Procedure and Equipment Qualification

The licensee is using type PE4710 (cell classification 445574C) polyethylene material that is traceable to the resin supplier and pipe manufacturer and their burst and impact-tensile test results. The personnel and equipment contracted by the licensee for testing will be under the licensee's 10 CFR 50, Appendix B program. The burst testing ensures that the piping will fail before a properly fabricated fused joint fails. The impact-tensile test is a quick go or no-go test on the fused joint's resistance to fracture. The impact-tensile test results that exhibit a ductile fracture are considered acceptable and those that exhibit a brittle fracture are rejectable.

The fusion procedure contains the essential variables necessary to make an acceptable joint and the "how to" process of fabricating the joint. The fusion procedure is specific to material, fusion process, configuration (elbow, pipe, diameter range, wall-thickness range), equipment, and essential variables. Essential variables affecting joint integrity are identified in Sections QF-221 and QF-222 of the licensee's submittal (Reference 7.1) as: pipe material (PE4710); heater surface temperature range (maximum/minimum); butt fusion interfacial pressure range (maximum/ minimum); heater bead-up size (maximum/minimum) which is indirectly tied to pipe diameter in Table QF-221(a)-1; heater removal time (fast/slow) which is indirectly tied to pipe wall thickness in Table QF-221(a)-2; and cool-down time under fusion pressure (minimum). The NRC staff believes that equipment model used for the fusion process also affects joint integrity and that large ambient temperature differences will also affect the fusion process. The NRC staff considers both equipment and ambient temperature as essential variables.

The 10 CFR Part 50, Appendix B, Criterion III specifies, in part, that qualification testing be performed on a prototype under the most adverse design conditions. Applying this criterion to the fusion procedure, the essential variable extremes must be demonstrated. Instead of demonstrating the effects from each essential variable extreme (high and low value of a range), the licensee grouped essential variable extremes by their thermal affect on the fusion process. The essential variable group that maximized HDPE plasticity was maximum heater plate temperature, high-ambient temperature, maximum joining force, and minimum joining dwell time. The essential variable group that minimized HDPE plasticity was minimum heater plate temperature, low-ambient temperature, minimum joining force, and minimum joining dwell time. For the licensee's application, the high- and low-ambient temperatures during the fusion process of pipe (50 degrees Fahrenheit (°F) to 75 °F) and fitting (65 °F to 75 °F) had negligible thermal effect on the fusion process. Therefore, ambient temperature was considered a constant.

The heater bead-up size is the result of thermal expansion of the HDPE pipe, without an applied load, against the heater plate. As the material acquires heat from the heater plate, it expands. Both the pipe and heater plate are stationary, thus the material flows along the heater plate and beads up on the inside diameter (ID) and outside diameter (OD) surfaces. The bead width on the pipe surface is a combination of material flow and thermal expansion. Intuitively, heater bead-up size should be associated with wall thickness because greater material volume flows to the surface. The licensee is using two specific pipe diameters with similar DR numbers (DR 9.0 and DR 9.5) which require a larger bead for the thicker wall pipe, i.e., 4-inch diameter, 0.5-inch wall, with a minimum bead size of 0.125 inches and 36-inch diameter, 4-inch wall, with a minimum bead size of 0.56 inches. Although, the bead-up size essential variable is expressed as a minimum and maximum, the minimum value indicates sufficient heat has been conducted into the pipe. The maximum value is for practical reasons because the heater plate and pipe approach a thermal equilibrium and the bead may sag from gravity.

The licensee's qualification process for the fusion procedure consisted of demonstrating capability, reliability, and effectiveness. To show capability, the licensee used the essential variable group extremes to produce joints from 4-inch nominal, DR 9.0 and 36-inch nominal DR 9.5, type PE4710 pipe. To show reliability, the licensee made three joints for each essential variable group or each pipe size. To show effectiveness, the licensee subjected each joint to a minimum of four impact-tensile tests with each test taken approximately 90-degrees apart around the circumference. From the 36-inch nominal DR 9.5 pipe at each test location, the licensee will take several impact-tensile tests to examine the effects of the thicker wall on the joint integrity. In the event that the impact-tensile test data from the 36-inch pipe is inconclusive, the licensee will perform a full-section tensile test.

The licensee used three different pieces of equipment (identified by manufacturer and model number) for fusing 36-inch and 4-inch piping and their associated fittings. Each piece of equipment was performance demonstrated using equipment-specific essential variables.

Based on the above, the NRC staff concluded that the licensee's process for demonstrating the capability, reliability, and joint effectiveness to qualify the fabrication procedure is, therefore, acceptable.

4.1.2 Fusion Operator Qualification

Technical Report TR-33/2006, "Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe," by PPI references Title 49 of the *Code of Federal Regulations* (49 CFR) Part 192 for fusion operator qualifications. Pursuant to 49 CFR 192.285(b)(2), joints are required to be ultrasonically tested or sectioned longitudinally in three locations and visually examined for voids or discontinuities on the cut surface.

The licensee qualified the fusion operators on 36-inch diameter 4-inch wall pipe using the same model equipment (McElroy Manufacturing and Ritmo America) and fusion procedure that will be used for making joints in the ESW piping. The qualification testing consisted of cutting a bend-test specimen from the ID and another from the OD surfaces, and bending each specimen until the ends touch. The test is acceptable if no cracks are observed in the bend region. As part of test preparation, the specimens are visually examined for evidence of voids and discontinuities. The making of fused joints using representative material, pipe diameter, and wall thicknesses, and the examination and bend testing of the joints demonstrate the fusion operator's ability to following the fusion procedure and make acceptable joints. Based on the above, the NRC staff concluded that the demonstration used by the licensee to qualify fusion operators is, therefore, acceptable.

4.1.3 Visual Examination Personnel Qualification

The licensee will provide a minimum of 16 hours of additional training to certify qualified VT-1 (visual examination) personnel for reviewing recorded fusion joining data and performing bead-appearance examinations. The licensee will give VT-1 personnel hands-on practice in operating HDPE fabrication equipment and in making fused butt joints. The VT-1 personnel must successfully pass a licensee-administered performance demonstration consisting of a combination of acceptable and unacceptable fused joints. A minimum of five flawed samples will be used for the VT procedure demonstration, and a minimum of five flawed samples will be used for personnel demonstrations using the VT procedure. In addition, inside surface examples of visually acceptable and unacceptable joints will be available to provide supplemental visual comparison standards for VTs. Based on the above, the NRC staff concluded that personnel successfully demonstrating their skills on representative mockups of acceptable and rejectable fused joints assures their proficiency and is, therefore, acceptable.

4.1.4 Ultrasonic Testing Personnel Qualification

The licensee will use contractor personnel with demonstrated ultrasonic testing (UT) skills in detecting volumetric flaws in the fused joint area of HDPE pipe. The contractor personnel will be under the licensee's 10 CFR 50, Appendix B program. The licensee will verify the personnel skills and UT technique with representative mockups containing ten flaws of varying shapes, dimensions, and relative locations in the fused joints. The current acceptance criterion is that any unbonded area in the joint that is detected with UT is rejected. Based on the above, the

NRC staff concluded that the performance demonstration provides verification of personnel skills and procedure effectiveness in detecting volumetric flaws and is, therefore, acceptable.

4.1.5 Visual and Ultrasonic Testing Examinations

The visual examiner will perform a VT-1 examination on the OD of the fusion joint bead and verify that the recorded data in the data logger is within the fusion procedure pressure and fusion time ranges. The UT examiner will use the time of flight diffraction technique to verify an absence of volumetric flaws in the joint region (a portion of the pipe end and the fused joint). Joints not conducive to UT examinations will be examined visually on both the ID and OD surfaces by the VT-1 examiner. Based on the above, the NRC staff concluded that the examinations for verifying joint integrity should detect detrimental flaws, if any, in the joint region and are, therefore, acceptable.

4.1.6 Process Control Criteria

The licensee is relying on guidance published in TR-33/2006 to identify the key variables that affect joint integrity and to identify the essential variables for fabrication process control. The licensee will be recording the essential variables (fusion time and pressure) with a data logger during the fusion process and recording the measured heater-plate temperature immediately after removal. The data being recorded is viewed by the fusion operator and VT-1 inspector. The recorded data from the data logger (pressure and fusion time) are reviewed for acceptance before the licensee buries the joint. If any variables deviate outside the acceptable ranges, the joint is cut out. In addition to the process control, the fused joint will be ultrasonically examined. The licensee will maintain the data logger information and inspection results. Based on the above, the NRC staff concluded that proposed process control is, therefore, acceptable.

4.1.7 Pressure Testing

The licensee will perform a hydrostatic test at 150 percent above the system design pressure. The piping will be examined for leakage by VT-2 qualified personnel. The licensee will provide the VT-2 personnel with 4 additional hours of training on HDPE fusion pipe joints. The hydrostatic test is effective in detecting existing though-wall flaws. However, because HDPE material flows over time, the hydrostatic test gives little, if any, information on embedded flaws which may grow over time. System monitoring will be used to detect leakage after the piping is buried. Based on the above, the NRC staff concluded that the proposed pressure testing is, therefore, acceptable.

4.1.8 Access for Future Testing

The use of HDPE pipe in ASME Code Class 3 piping systems is new to the U.S. nuclear power industry. To address unknown integrity issues that may appear after burying the piping, the licensee committed to provide access points in the ESW system for future examinations from the inside surface. Based on the above, the NRC staff concluded that the provision for the accessibility of the pipe inside surface examination is therefore, acceptable.

4.1.9 Fittings

For gas pipe lines, TR-33/2006 requires that fused joints satisfy 49 CFR 192.283 which states that the procedure must be qualified by subjecting specimen joints made according to the following two criteria: (1) the burst test requirements of a sustained pressure test, minimum hydrostatic burst test or sustained static pressure test, and (2) the lateral pipe connection tests which subject the pipe and 90-degree fitting to a force until failure or a tensile test. The licensee intends on performing testing similar to the 49 CFR Part 192 requirements. The fittings are made from type PE4710 material, the same as the piping. For criterion (1), the licensee will subject the HDPE pipe to a system pressure test at 150 percent above design pressure. For criterion (2), the licensee will use fittings with thicker walls than the system pipe. Since the pipe joints are routinely impact-tensile tested, the pipe side of the fitting to pipe should fail before the fitting joints fail. Based on the above, the NRC staff concluded that the test program for the fittings is, therefore, acceptable.

4.2 Structural integrity and design evaluation

Union Electric Company is the first licensee to request utilizing PE4710 material HDPE piping in a safety-related ASME Code, Section III Class 3 application at its Callaway plant with temperatures higher than 140 °F (degrees Fahrenheit), pressures higher than 150 psig (pounds per square inch gauge), and diameters larger than 12.75 inches. As the ASME Code, Section III, Subsection ND, 1974 Edition through Summer 1975 Addenda, which is the Construction Code, as well as later editions and addenda, do not provide rules for the design, fabrication, installation, examination, and testing of piping constructed using polyethylene material, the NRC staff performed a review of the licensee's analyses. The results of the NRC staff's evaluations are provided in the following sections of this safety evaluation.

4.2.1 ASME Code Case N-755

The licensee was requested by the NRC staff to supplement the RR I3R-10 to address specific aspects of ASME Code Case N-755 not endorsed by the NRC staff. NRC's review of the methodology utilized in the RR I3R-10 is specific for the Callaway application only. The industry is engaged in an extensive ongoing testing program to establish the full range of properties, fatigue data, stress-intensification factors, long-term creep rupture data, and slow crack-growth characteristics for the specific grade of PE material (PE4710) to be utilized in the requested Callaway application. The current test data that support a fatigue allowable of 1100 psi for PE4710 material is very limited. More investigations are needed to confirm the short-duration (30 days) stress allowables and applicable design factors. Furthermore, techniques to ensure the structural integrity of fusion joints are still evolving. Finally, there is currently no domestic performance or operating experience history regarding PE4710 piping's use in nuclear safety-related applications.

In the letter dated July 10, 2008, the licensee made a regulatory commitment to evaluate future investigations performed by the industry to confirm the short-duration (30-day) stress allowables and applicable design factors for PE4710 piping. The licensee also committed to evaluate future refinement of the fusion technique to confirm structural integrity of the installed fusion joints. The results will be submitted to the NRC staff prior to submittal of Callaway's fourth 10-year ISI interval, and will include, if necessary, a fourth 10-year ISI interval alternative request. The NRC staff reviewed the supplemental information and the regulatory commitment made by the licensee and finds them reasonable.

4.2.2. Acceptability of Flaws

In its letter dated July 10, 2008, the licensee responded to the NRC staff's question on acceptability of any flaws that may be present in HDPE piping. In that letter, the licensee provided the following information on how it will address the flaws in polyethylene piping within the scope of the RR I3R-10:

- For 4-inch diameter ESW backwash piping, any section with a flaw exceeding 10 percent of the wall thickness shall be cut out and replaced. For 36-inch diameter ESW supply and return piping, any section with a flaw exceeding 7 percent of the wall thickness shall be cut out and replaced. Any section of piping with a flaw not exceeding 5 percent of the wall thickness may be left as-is.

- All other flaws shall be removed by blending. The depression after flaw elimination is blended uniformly into the surrounding surface with a maximum taper not to exceed width to height ratio of 3 to 1. After flaw elimination, the area will be examined by VT to ensure that the flaw has been removed. If the elimination of the flaw reduces the thickness of the section below the minimum required design thickness, the section of piping containing the flaw shall be cut out and replaced.

Based on the above, the NRC staff concluded that the approach provided by the licensee to address the damage to the polyethylene piping due to the presence of any flaws indicated is acceptable, as the minimum required design thickness will be maintained.

4.2.3 Design Factor

Design factors are used to enhance safety in engineering calculation of acceptable strength of materials. The preliminary stress calculations reviewed by the NRC staff are based on a design factor of 0.5. With regard to the design factor, the staff reiterated that the use of a design factor greater than 0.5 in HDPE piping stress evaluations is not acceptable. The licensee committed to use a design factor of 0.5 in the final calculations which the staff finds acceptable.

On September 19, 2008, the NRC staff conducted a phone call with the licensee. During that phone call, the NRC staff asked the licensee to provide its calculation for thermal gradient stress analysis. In its October 9, 2008, response (Reference 7.4), the licensee provided a calculation addressing the thermal gradient stresses. The NRC staff concluded that the results of the calculation are acceptable. In the October 9, 2008, response, the licensee's calculation was based on a design factor (DF) of 0.5, and another calculation was based on a DF of 0.56, which had a notation "for information only." The NRC staff does not accept the use of DF of 0.56. The NRC staff's evaluation of the relief request is based only on results corresponding to a DF of 0.50.

4.2.4 Stress Evaluation

The NRC staff conducted an independent evaluation to verify the hoop stress in polyethylene pipe from internal pressure and equivalent external pressure based on thick pressure vessel formulas provided in References 7.1 and 7.2 (thin-pressure vessel formulas). Because the wall thickness of the polyethylene piping is much larger than carbon steel piping and the diameter to thickness ratio of the HDPE piping associated with the RR I3R-10 is much less than 20, the staff considers thick vessel formulas more appropriate for calculating the pressure stresses. The circumferential or hoop stress (σ) due to pressure calculated based on thin vessel formula ($P.D_{avg}/2.t$) used for minimum required wall thickness (t_{min}) calculation from internal pressure in section 3021.1, and circumferential compressive stress in the side walls due to external pressure in section 3032 of Reference 7.1, are not conservative compared to the more accurate thick vessel formulas listed below.

Circumferential or hoop stress due to internal pressure:

P = Internal design pressure; D_o = outside diameter; t = wall thickness; D_{avg} = average diameter
a = outside radius; b=inside radius; σ = Circumferential stress for thin vessel = $P.D_{avg}/(2.t)$
σ = Circumferential stress for thick vessel from internal pressure = $P(a^2+b^2)/(a^2-b^2)$

	P psig	D_o inch	t inch	D_{avg} inch	D_{avg}/t	a inch	b inch	Thin σ psi	Thick σ psi	Allowable psi
ESW Supply	165	36	3.85	32.15	8.35	18	14.15	689	699*	695
ESW Return	45	36	3.85	32.15	8.35	18	14.15	188	191	340
Backwash	160	4.5	0.50	4.0	8	2.25	1.75	640	650	695

* The hoop stress of 699 pounds per square inch (psi) due to internal pressure based on thick vessel formula slightly exceeds the allowable stress of 695 psi for the supply line, which is based on a design factor (DF=0.5) or factor of safety of 2. This very slight excedance raises the design factor from 0.5 to 0.503 or lowers the factor of safety from 2.0 to 1.989. As this reduction in factor of safety is extremely small, the NRC staff finds it to be acceptable.

Circumferential compressive stress in side walls of pipe due to external pressure:

σ = Circumferential stress for thick vessel from external pressure = $2\,P(a^2)/(a^2-b^2)$
P = Equivalent external pressure

	P psig	D_o inch	t inch	D_{avg} inch	D_{avg}/t	a inch	b inch	Thin σ psi	Thick σ psi	Allowable psi
ESW Supply	15.8	36	3.85	32.15	8.35	18	14.15	66	83	695
ESW Return	15.8	36	3.85	32.15	8.35	18	14.15	66	83	340
Backwash	8.25	4.5	0.50	4.0	8	2.25	1.75	33	42	695

The circumferential compressive stress in the side walls due to external pressure from thick vessel formula is higher than the one from the thin vessel formula, but it is still acceptable because the margin is sufficient.

In response to a question regarding the constant 1000 psi allowable stress used in checking the circumferential compressive stress in the side walls of HDPE pipe, the licensee agreed to use the temperature-dependent stress allowable in lieu of 1000 psi in the final stress calculation. In letter dated September 15, 2008 (Reference 7.3), the licensee stated that the final stress calculations include the temperature-dependent stress allowable. Based on the above, the NRC staff concludes this is acceptable.

The NRC staff noted that the stress evaluations and summaries included in the preliminary stress calculation were for straight pipe locations only and did not include critical miter bend locations with the applicable stress indices and stress intensification factors. The licensee agreed to include stress summaries for miter bend locations in the final stress calculations. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations summarize the stresses at critical miter bend locations. Based on the above, the NRC staff concludes this is acceptable.

The NRC staff questioned the validity of not considering the torsional moment in the HDPE piping stress evaluations. In its response, the licensee stated that the final stress calculations will consider all three moment components including the torsional moment. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations include all three moment components including torsion. Based on the above, the NRC staff concludes this is acceptable.

In a request for additional information, the NRC staff stated that the alternative thermal stress evaluation should be based on the maximum range of all thermal load cases rather than stress check based on individual load cases. In its response the licensee stated that in the final calculations, the alternative thermal stress will be based on maximum range of all thermal load cases. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations are based on the maximum range of all thermal load cases. Based on the above, the NRC staff concludes this is acceptable.

In the preliminary calculations reviewed by the NRC staff, the upward buoyant force in flotation analysis of the buried HDPE pipe was based on the ID of the pipe. The staff pointed that it should be based on the OD of the pipe. In its response, the licensee indicated that in the final calculations, the buoyant force will be calculated based on the OD of the buried pipe. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations utilize the OD of the pipe for the upward buoyant force computation. Based on the above, the NRC staff concludes this is acceptable.

5.0 REGULATORY COMMITMENT

In its letter dated July 10, 2008 (Reference 7.1, Enclosure 7), the licensee made the following regulatory commitment:

COMMITMENT	Due Date/Event
AmerenUE will evaluate future investigations performed by the industry to confirm the short-duration (30-day) stress allowables and applicable design factors for PE4710 piping. AmerenUE will also evaluate future evolution of the fusion technique to validate structural integrity of the installed fusion joints. The results of the evaluations will be submitted to the NRC prior to submittal of Callaway's fourth 10-year interval ISI plan, and will include, if necessary, a fourth 10-year ISI interval alternative request.	Prior to submittal of Callaway's inservice inspection plan for the fourth 10-year interval.

6.0 CONCLUSION

Based on the above evaluation, the NRC staff concludes that the use of HDPE pipe for the buried section of the ESW system, (ASME Code Class 3, 4-inch DR 9.0 and 36-inch DR 9.5 piping) as described in the RR I3R-10 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of HDPE pipe for the buried section of the ESW system in lieu of the carbon steel piping for Callaway's third 10-year ISI interval which is scheduled to end on December 18, 2014..

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

7.0 REFERENCES

7.1 Luke H. Graessle, AmerenEU, Letter to NRC, "10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated July 10, 2008 (ADAMS Accession No. ML082470210).

7.2 Luke H. Graessle, Ameren EU, Letter to NRC, "Follow-up Information Regarding 10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated April 17, 2008 (ADAMS Accession No. ML081190648).

7.3 L. H. Graessle, AmerenEU, Letter to NRC, "Additional Information Regarding 10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated September 15, 2008 (ADAMS Accession No. ML082630806).

7.4 Luke H. Graessle, AmerenEU, Letter to NRC, "Follow-up Information Regarding 10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated October 9, 2008 (ADAMS Accession No. ML082900027).

Principal Contributors: D. Naujock
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Date: October 31, 2008

ATTACHMENT 4

CALCULATION 2007-16760 REVISION 2 ADDENDUM 2

2007-16760 Rev. 2 Add. 2

Determine the Pipe Stress in HDPE Lines EF-003-AZC-36", EF-007-AZC-36", EF-083-AZC-36", and EF-140-AZC-36"

January 10, 2013

Responsible Engineer: Christine Norman
Qualified Reviewer: Nicole Green
Supervisor Approval: Bruce Huhmann

Work Order: CALC00002330

1.0 PURPOSE

The purpose of this addendum is to show that the above ground high density polyethylene (HDPE) piping in the ESW system located in Control Building Room 3101 and the UHS Cooling Tower is of sufficiently low stress, such that a break need not be postulated.

2.0 METHODOLOGY

Chapter 3 of the Callaway FSAR provides the licensing basis for the postulation and evaluation of high and moderate energy line breaks. Based on the criteria in Chapter 3.6.1.1, the ESW system piping is considered moderate energy.

A moderate energy pipe failure is defined in Nuclear Regulatory Commission (NRC) Branch Technical Positions (BTP) ASB 3-1 and MEB 3-1, which are contained in FSAR Table 3.6-2. Unless the piping meets one of the exceptions listed in FSAR Section 3.6.2.1.2.4, the moderate energy pipe failure for safety related, and seismically qualified components, is defined as a crack with an area half the wall thickness of the pipe by half the internal diameter.

FSAR Section 3.6.2.1.2.4(c) contains an exception for piping designed to ASME Section III, Class 2 or 3, and non-nuclear seismic Category 1 class piping. This exception requires the maximum stress range in the piping, as calculated by the sum of Equation 9 and Equation 10 in Subarticle NC-3652 of the ASME Code Section III, considering normal and upset plant conditions, to be less than $0.4(1.2S_h+S_A)$. If the stress criterion is met, then a moderate energy pipe crack is no longer required to be postulated.

This statement is based on NRC Branch Technical Position (BTP) MEB 3-1, *Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment*, which is attached to Chapter 3.6.2 of NUREG-0800. The background section of MEB 3-1 states;

> "Our observations of actual piping failures have indicated that they generally occur at high stress and fatigue locations, such as at the terminal ends of a piping system at its connection to the nozzles of a component. The rules of this position are intended to utilize the available piping design information by postulating pipe ruptures at locations having relatively higher potential for failure, such that an adequate and practical level of protection may be achieved."

3.0 ASSUMPTIONS

The maximum stress limit of $0.4(1.2S_h+S_A)$ is intended to be a stress threshold to identify piping sections of sufficiently low stress such that failure at these locations is unlikely and therefore need not be postulated.

4.0 DESIGN INPUTS

The HDPE ESW piping was designed in accordance with Relief Request I3R-10. As such, Equations 9 and 10 and the allowable pipe stresses, S_h and S_A of ASME Section III ND-3600, were not explicitly used. However, the following correlations can be made to equate the design equations from Relief Request I3R-10 to the exception allowed in FSAR Section 3.6.2.1.2.4(c).

- The allowable stress, S, in APA-ZZ-00662 App. F, which houses the commitments and design requirements contained in Relief Request I3R-10, is equivalent to the ND-3600 stress allowable of S_h. Both are defined as the allowable stress (i.e. maximum acceptable stress level) at the maximum design temperature.
- The *Service Level B Longitudinal Stress Equation* utilized in calculation 2007-16760 for the HDPE piping via APA-ZZ-00662 App. F is equivalent to ND-3600 Equation 9, also for Service Level B.
    - FSAR Table 3.9(N)-4 provides a listing and definition for Service Levels A, B, C, and D. As described in the Methodology Section, FSAR Chapter 3.6.2.1.2.4(c) requires the sum of Equations 9 and 10, considering normal and upset plant conditions, to be less than $0.4(1.2S_h+S_A)$. As shown in FSAR Table 3.9(N)-4, the upset condition is synonymous with Service Level B.
- The *Alternative Thermal Expansion or Contraction Evaluation* equation in calculation 2007-16760 can be compared to ND-3600 Equation 10 for thermal expansion.
    - APA-ZZ-00662 App. F, Section 3042.3 lists the *Alternative Thermal Expansion or Contraction Evaluation* equation, which is also shown below.

$$\frac{iM_C}{Z}+\frac{F_{aC}}{A}\leq 1100psi$$

-
    - The first term (iM_C/Z) is identical for the *Alternative Thermal Expansion or Contraction Evaluation* equation and ND-3600 Equation 10. In addition the *Alternative Thermal Expansion or Contraction Evaluation* equation adds a second term (F_{aC}/A), where F_{aC} is the axial force range due to thermal expansion or contraction and/or the restraint of free end displacement and A is the cross-sectional area of the pipe. The addition of the second term would yield higher stress results than ND-3600 Equation 10, which is conservative.
- The 1100 psi in the *Alternative Thermal Expansion or Contraction Evaluation* equation is equivalent to ND-3600 allowable stress range, S_A, seen in Equation 10 for thermal expansion.

Per FSAR 3.6.1.1(d), when a leakage crack in moderate energy fluid system piping is postulated, each crack is considered separately as a single postulated initial event occurring during normal plant conditions. Thus, the allowable stresses for the supply and return lines are based on normal operating conditions, as opposed to those present during a design basis event.

- The allowable stress for the supply lines is 695 psi based on an operating temperature of 95°F, which is the maximum allowable pond temperature. [Ref. Calculation 2007-13241 Rev. 2, Table 2.8-1 or APA-ZZ-00662 App. F Table 3021-1]
- The allowable stress used for the return lines is 613 psi based on an operating temperature of 113°F, which is greater than the maximum allowable temperature for water returning to the pond during normal operating conditions. However, this was the closest value listed in Calculation 2007-13241 Rev. 2, Table 2.8-1 (or APA-ZZ-00662 App. F) and is conservative.
- Note that a design factor of 0.50 is required to be used per NRC SER I3R-10. Thus, Table 2.8-1 of calculation 2007-13241 must be used, as opposed to Table 2.8-2.

5.0 CALCULATION

Background:
The HDPE piping for all of the ESW supply and return lines installed by MP 07-0066 is analyzed in calculation 2007-16760. The preliminary design for the installation of HDPE piping included piping anchors on the stainless steel piping near the transition flanges between the HDPE and the stainless steel piping. However, the design was revised to eliminate the anchors, which were never installed.

Calculation 2007-16760 was initially performed under the assumption that the anchors would be installed. After the decision was made to eliminate the anchors, calculation 2007-16760 was revised. However, the revision did not rerun the model after removing the anchors. Instead their removal was justified via the analysis performed in Section B2.4 of newly added Appendix B.

As a result, the stresses listed in the output files of 2007-16760 do not reflect actual plant conditions since they are based on a model that contains anchors that do not exist. Although the model for 2007-16760 was not updated after the elimination of the anchors, all of the models for the interfacing calculations (2007-18080, 2007-18081, 2007-18082, 2007-18083, and 2007-16601) for the metallic piping were. Section B2.4 of Appendix B uses the peak axial forces and resultant moments from interfacing calculations 2007-18080, 2007-18081, 2007-18082, 2007-18083, and 2007-16601 to determine the actual stresses in the HDPE in the as-built condition using the equations in 2007-16760 Section 6.2.1 (page 25). Section B2.4 states that the calculated stresses for the as-built condition will be compared to the calculated preliminary design values. Although not explicitly called out, the first two lines in each table in Appendix B2.4 are the original HDPE values from calculation 2007-16760 and the remaining rows were updated as described above. All of the as-built stresses calculated in Appendix B are below the allowable stresses established in APA-ZZ-00662 App. F and are therefore acceptable.

This situation was further complicated by MP 10-0003, which installed check valves on the service water supply piping near the tie-ins to ESW to prevent voiding if a Safety Injection Signal were to occur. Calculations EF-119 and EF-120 were created to reanalyze the ESW and Service Water supply piping, which was previously analyzed in 2007-18080 and 2007-18081. This calculation addendum calculates the stresses at the HDPE to stainless steel interface in the Control Building basement due to the configuration modeled in EF-119 and EF-120, as opposed to 2007-18080 and 2007-18081. All of the as-built stresses calculated in Appendix B and in this addendum are below the allowable stresses established in APA-ZZ-00662 App. F and are therefore acceptable.

Evaluation:

ESW Supply Line Analysis:
The equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW supply lines in Control Building Room 3101 is calculated below.

$$0.4(1.2S_h + S_A) = 0.4(1.2 \times 695 + 1100) = 773.6psi$$

The *Service Level B Longitudinal Stress* must be calculated for the ESW HDPE supply lines in the Control Building basement using the equation found in paragraph -3035.1 of APA-ZZ-00662 App. F, which is defined below. Note that the section of HDPE in the Control Building Basement consists solely of straight pipe and butt fused joints.

$$B_1 \times \frac{P_a \times D}{2 \times t} + 2 \times B_1 \times \frac{F_a}{A} + B_2 \times \frac{M}{Z}$$

B_1 = 0.5 = Stress index, Table 3035-1 [Ref. APA-ZZ-00662 App. F]
B_2 = 1.0 = Stress index, Table 3035-1 [Ref. APA-ZZ-00662 App. F]
P_a = 190 = Design or Service Level A, B, C, or D pressure (psi) [Ref. 2007-16760 Section 4.3]
D = 36 = Outside pipe diameter at the pipe section where the evaluation is conducted (in) [Ref. 2007-16760 Section 4.5]
t = 3.789 = Nominal pipe wall thickness at the pipe section where the evaluation is conducted (in) [Ref. 2007-16760 Section 7.1.1]
F_a = Axial force due to the specified Design Level A, B, C, or D applied mechanical loads (lb)
A = 383.42 = Cross sectional area of the pipe wall at the pipe section where the force is calculated (in^2) [Ref. 2007-16760 Section 7.4]
M = Resultant bending moment due to the specified Design Level A, B, C, or D applied mechanical loads (in-lb)
Z = 2800.87 = Section modulus of pipe cross section at the pipe section where the moment is calculated (in^3) [Ref. 2007-16760 Section 7.5.1]

In order to determine the *Service Level B Longitudinal Stress,* the axial force due to Design Level B applied mechanical loads (F_a) and resultant bending moment due to Design Level B applied mechanical loads (M) must be calculated.

Control Building Room 3101

For the seismic load case the term F_a is the absolute sum of the OBE axial stress value and the square-root-sum-of-the-square (SRSS) of the X, Y, and Z SAM values, which can be found in EF-119 Rev. 0 for node 120 (A Train) and EF-120 Rev. 0 for node 40 (B Train). The stresses for both trains were calculated and reviewed against moderate energy crack criteria.

$$F_{aATrain} = 1466 + 1119 = 2585 lb$$
$$F_{aBTrain} = 1204 + 1245 = 2449 lb$$

The moment, M, is found by first calculating the individual moments, which are the absolute sums of the OBE case values and the SRSS of the X, Y, and Z SAM case values. The resultant moment is the SRSS of the individual moment values.

Individual Moment Values

$$M_{XATrain} = 8090 + 2367 = 10457 ft \cdot lb$$
$$M_{YATrain} = 15360 + 1354 = 16714 ft \cdot lb$$
$$M_{ZATrain} = 552 + 53 = 605 ft \cdot lb$$

$$M_{XBTrain} = 3087 + 3128 = 6215 ft \cdot lb$$
$$M_{YBTrain} = 17714 + 841 = 18555 ft \cdot lb$$
$$M_{ZBTrain} = 629 + 49 = 678 ft \cdot lb$$

Resultant Moment Values

$$M_{ATrain} = \sqrt{10457^2 + 16714^2 + 605^2} = 19725 ft \cdot lb = 236699 in \cdot lb$$
$$M_{BTrain} = \sqrt{6215^2 + 18555^2 + 678^2} = 19580 ft \cdot lb = 234959 in \cdot lb$$

Next, the *Service Level B Longitudinal Stress* can be calculated for each train.

A Train Supply

$$0.5 \times \frac{190 \times 36}{2 \times 3.789} + 2 \times 0.5 \times \frac{2585}{383.42} + 1.0 \times \frac{236699}{2800.87} = 542.56 psi$$

B Train Supply

$$0.5 \times \frac{190 \times 36}{2 \times 3.789} + 2 \times 0.5 \times \frac{2449}{383.42} + 1.0 \times \frac{234959}{2800.87} = 541.58 psi$$

Note the minimum wall thickness is used as opposed to the nominal wall thickness to calculate the cross-sectional area and section modulus, which adds conservatism to the results.

The *Alternative Thermal Expansion or Contraction Stress* must be calculated next. The resultant axial force due to thermal expansion and contraction over the temperature range of the piping is calculated below, using the output for EF-119 Rev. 0 for node 120 (A Train) and EF-120 Rev. 0 for node 40 (B Train).

$$\frac{iM_C}{Z} + \frac{F_{aC}}{A} < 1100 psi$$

F_{aC} = Resultant axial force due to range of thermal expansion and contraction (lbf)
A = 383.42 = Cross sectional area of the pipe wall at the pipe section where the force is calculated (in^2) [Ref. 2007-16760 Section 7.4]
M_C = Resultant moment due to range of thermal expansion and contraction (in-lbf)
Z = 2800.87 = Section modulus of pipe cross section at the pipe section where the moment is calculated (in^3) [Ref. 2007-16760 Section 7.5.1]
i = 1.0 = Stress Intensification Factor, Table 3042.2-1 of APA-ZZ-00662 Appendix F

In order to determine the *Alternative Thermal Expansion or Contraction Stress,* the resultant axial force due to range of thermal expansion (F_{aC}) and resultant bending moment due to range of thermal expansion (M_C) must be calculated.

For the thermal load case the term F_{aC} is the absolute sum of the axial thermal stress value of the hot and cold thermal cases, which can be found in EF-119 Rev. 0 for node 120 (A Train) and EF-120 Rev. 0 for node 40 (B Train). The stresses for both trains were calculated and reviewed against moderate energy crack criteria.

$$F_{aC\_ATrain} = 4026 + 6132 = 10158 lb$$
$$F_{aC\_BTrain} = 5108 + 7780 = 12888 lb$$

The moment, M_C, is found by first calculating the individual moments, which are the absolute sums of the hot and cold thermal case values. The resultant moment is the SRSS of the individual moment values.

Individual Moment Values

$$M_{CX\_ATrain} = 8388 + 12772 = 21160 ft \cdot lb$$
$$M_{CY\_ATrain} = 4761 + 7242 = 12003 ft \cdot lb$$
$$M_{CZ\_ATrain} = 84 + 127 = 211 ft \cdot lb$$

$$M_{CX\_BTrain} = 12953 + 19715 = 32668 ft \cdot lb$$
$$M_{CY\_BTrain} = 2380 + 3616 = 5996 ft \cdot lb$$
$$M_{CZ\_BTrain} = 74 + 112 = 186 ft \cdot lb$$

Resultant Moment Values

$$M_{C\_ATrain} = \sqrt{21160^2 + 12003^2 + 211^2} = 24328 ft \cdot lb = 291939 in \cdot lb$$
$$M_{C\_BTrain} = \sqrt{32668^2 + 5996^2 + 186^2} = 33214 ft \cdot lb = 398571 in \cdot lb$$

Next, the *Alternative Thermal Expansion or Contraction Stress* can be calculated for each train.

A Train Supply

$$\frac{1.0 \times 291939}{2800.87} + \frac{10158}{383.42} = 130.7 psi$$

B Train Supply

$$\frac{1.0 \times 398571}{2800.87} + \frac{12888}{383.42} = 175.9 psi$$

The *Service Level B Longitudinal Stress* must be added to the *Alternative Thermal Expansion or Contraction Stress.*

A Train Supply
$$542.56 + 130.7 = 673.26 psi$$

B Train Supply
$$541.58 + 175.9 = 717.48 psi$$

The sum of the *Service Level B Longitudinal Stress* and *Alternative Thermal Expansion or Contraction Stress* is 673.26 psi for the A Train ESW Supply piping and 717.48 psi for the B Train ESW Supply piping. This is less than the equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW supply lines, which is 773.6 psi. Therefore, a moderate energy crack is not required to be postulated on the ESW HDPE Supply piping in Room 3101.

ESW Return Line Analysis:

The equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW return lines is calculated below.

$$0.4(1.2S_h + S_A) = 0.4(1.2 \times 613 + 1100) = 734.2 psi$$

The *Service Level B Longitudinal Stress* must be calculated for the ESW HDPE return lines in the Control Building basement using the equation found in paragraph -3035.1 of APA-ZZ-00662 App. F, which is defined below. Note that the section of HDPE in the Control Building Basement consists solely of straight pipe and butt fused joints.

$$B_1 \times \frac{P_a \times D}{2 \times t} + 2 \times B_1 \times \frac{F_a}{A} + B_2 \times \frac{M}{Z}$$

B_1 = 0.5 = Stress index, Table 3035-1 [Ref. APA-ZZ-00662 App. F]
B_2 = 1.0 = Stress index, Table 3035-1 [Ref. APA-ZZ-00662 App. F]
P_a = 45 = Design or Service Level A, B, C, or D pressure (psi) [Ref. 2007-16760 Section 4.3]
D = 36 = Outside pipe diameter at the pipe section where the evaluation is conducted (in) [Ref. 2007-16760 Section 4.5]
t = 3.789 = Nominal pipe wall thickness at the pipe section where the evaluation is conducted (in) [Ref. 2007-16760 Section 7.1.2]
F_a = Axial force due to the specified Design Level A, B, C, or D applied mechanical loads (lb)
A = 383.42 = Cross sectional area of the pipe wall at the pipe section where the force is calculated (in^2) [Ref. 2007-16760 Section 7.4]
M = Resultant bending moment due to the specified Design Level A, B, C, or D applied mechanical loads (in-lb)
Z = 2800.87 = Section modulus of pipe cross section at the pipe section where the moment is calculated (in^3) [Ref. 2007-16760 Section 7.5.2]

In order to determine the *Service Level B Longitudinal Stress,* the axial force due to Design Level B applied mechanical loads (F_a) and resultant bending moment due to Design Level B applied mechanical loads (M) must be calculated.

Control Building Room 3101

For the seismic load case the term F_a is the absolute sum of the OBE axial stress value and the square-root-sum-of-the-square (SRSS) of the X, Y, and Z SAM values, which can be found in 2007-18082 Rev. 2 for node 3 (A Train) and 2007-18083 Rev. 1 for node 5 (B Train). The stresses for both trains was calculated and reviewed against moderate energy crack criteria.

$$F_{aATrain} = 6729 + \sqrt{48^2 + 65^2 + 338^2} = 7077 lb$$

$$F_{aBTrain} = 2418 + \sqrt{0^2 + 78^2 + 416^2} = 2841 lb$$

The moment, M, is found by first calculating the individual moments, which are the absolute sums of the OBE case values and the SRSS of the X, Y, and Z SAM case values. The resultant moment is the SRSS of the individual moment values.

Individual Moment Values

$$M_{XATrain} = 7474 + \sqrt{79^2 + 211^2 + 587^2} = 8103 ft \cdot lb$$

$$M_{YATrain} = 11755 + \sqrt{218^2 + 60^2 + 277^2} = 12113 ft \cdot lb$$

$$M_{ZATrain} = 655 + \sqrt{10^2 + 5^2 + 1^2} = 666 ft \cdot lb$$

$$M_{XBTrain} = 3497 + \sqrt{0^2 + 296^2 + 883^2} = 4428 ft \cdot lb$$

$$M_{YBTrain} = 13781 + \sqrt{242^2 + 5^2 + 2^2} = 14023 ft \cdot lb$$

$$M_{ZBTrain} = 673 + \sqrt{11^2 + 0^2 + 0^2} = 684 ft \cdot lb$$

Resultant Moment Values

$$M_{ATrain} = \sqrt{8103^2 + 12113^2 + 666^2} = 14588 ft \cdot lb = 175063 in \cdot lb$$

$$M_{BTrain} = \sqrt{4428^2 + 14023^2 + 684^2} = 14721 ft \cdot lb = 176657 in \cdot lb$$

Next, the *Service Level B Longitudinal Stress* can be calculated for each train.

A Train Return

$$0.5 \times \frac{45 \times 36}{2 \times 3.789} + 2 \times 0.5 \times \frac{7077}{383.42} + 1.0 \times \frac{175063}{2800.87} = 187.85 psi$$

B Train Return

$$0.5\times\frac{45\times36}{2\times3.789}+2\times0.5\times\frac{2841}{383.42}+1.0\times\frac{176657}{2800.87}=177.37\,psi$$

Note the minimum wall thickness is used as the nominal wall thickness to calculate the cross-sectional area and section modulus, which adds conservatism to the results.

The *Alternative Thermal Expansion or Contraction Stress* must be calculated next. The resultant axial force due to thermal expansion and contraction over the temperature range of the piping is calculated below, using the output for 2007-18082 Rev. 2 for node 3 (A Train) and 2007-18083 Rev. 1 for node 5 (B Train).

$$\frac{iM_C}{Z}+\frac{F_{aC}}{A}<1100\,psi$$

F_{aC} = Resultant axial force due to range of thermal expansion and contraction (lbf)
A = 383.42 = Cross sectional area of the pipe wall at the pipe section where the force is calculated (in^2) [Ref. 2007-16760 Section 7.4]
M_C = Resultant moment due to range of thermal expansion and contraction (in-lbf)
Z = 2800.87 = Section modulus of pipe cross section at the pipe section where the moment is calculated (in^3) [Ref. 2007-16760 Section 7.5.1]
i = 1.0 = Stress Intensification Factor, Table 3042.2-1 of APA-ZZ-00662 Appendix F

For the thermal load case for the A Train the term F_{aC} is the absolute sum of the axial thermal stress value of the hot and cold thermal cases, which can be found in 2007-18082 Rev. 2 for node 3 (A Train). A Loss of Coolant Accident (LOCA) is not required to be postulated coincident with a pipe break. Therefore, the thermal case for LOCA will not be included in the A Train analysis.

For the thermal load case for the B Train the term F_{aC} is determined using the LOCA thermal loads because calculation 2007-18083 Rev. 1 applied thermal loads for the Service Water line-up, as opposed to the ESW line-up. As a result it was decided to use the LOCA loads, which are much higher, as opposed to the loads listed in the output files for the thermal hot and cold cases. The LOCA loads are calculated using a design temperature of 175°F, as opposed to 105°F, which will result in much higher thermal expansion loads than would be present during normal operation. Because the *Alternative Thermal Expansion or Contraction Stress* requires input from the stress range, which includes the thermal contraction case for normal operating temperatures of 33°F, the LOCA loads will be doubled. The forces due to expansion from 70°F to 175°F will bound the forces due to contraction from 70°F to 33°F. When applied as normal operating loads, the use of LOCA loads makes the *Alternative Thermal Expansion or Contraction Stress* case very conservative. Calculation 2007-18083 Rev. 1 is the analysis of record for the B Train return line and the loads for node 5 apply to this calculation.

As stated above, a Loss of Coolant Accident (LOCA) is not required to be postulated coincident with a pipe break. However, the thermal loads for the LOCA case were used for conservatism for the B Train *Alternative Thermal Expansion or Contraction Stress* calculation. The stresses for both trains were calculated and reviewed against moderate energy crack criteria.

$$F_{aC\_ATrain} = 4673 + 5497 = 10170 lb$$
$$F_{aC\_BTrain} = 2 \times 10990 = 21980 lb$$

For the A Train the moment, M_C, is found by first calculating the individual moments, which are the absolute sums of the hot and cold thermal case values. The resultant moment is the SRSS of the individual moment values.

For the B Train the moment, M_C, is equivalent to double the individual moments for the LOCA case. The resultant moment is the SRSS of the individual moment terms. Again, using the thermal moments for the LOCA case is a conservative approach.

Individual Moment Values

$$M_{CX\_ATrain} = 8237 + 9646 = 17883 ft \cdot lb$$
$$M_{CY\_ATrain} = 4335 + 4887 = 9222 ft \cdot lb$$
$$M_{CZ\_ATrain} = 115 + 92 = 207 ft \cdot lb$$

$$M_{CX\_BTrain} = 2 \times 24078 = 48156 ft \cdot lb$$
$$M_{CY\_BTrain} = 2 \times 407 = 814 ft \cdot lb$$
$$M_{CZ\_BTrain} = 2 \times 47 = 94 ft \cdot lb$$

Resultant Moment Values

$$M_{C\_ATrain} = \sqrt{17883^2 + 9222^2 + 207^2} = 20121 ft \cdot lb = 241462 in \cdot lb$$
$$M_{C\_BTrain} = \sqrt{48156^2 + 814^2 + 94^2} = 48163 ft \cdot lb = 577956 in \cdot lb$$

Next, the *Alternative Thermal Expansion or Contraction Stress* can be calculated for each train.

A Train Return

$$\frac{1.0 \times 241462}{2800.87} + \frac{10170}{383.42} = 112.73 psi$$

B Train Return

$$\frac{1.0 \times 577956}{2800.87} + \frac{21980}{383.42} = 263.67 psi$$

The *Service Level B Longitudinal Stress* must be added to the *Alternative Thermal Expansion or Contraction Stress.*

A Train Return

$$187.85 + 112.73 = 300.58psi$$

B Train Return

$$177.37 + 263.67 = 441.04psi$$

The sum of the *Service Level B Longitudinal Stress* and *Alternative Thermal Expansion or Contraction Stress* is 300.58 psi for the A Train ESW Return piping and 441.04 psi for the B Train ESW Return piping. This is less than the equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW return lines, which is 734.2 psi. Therefore, a moderate energy crack is not required to be postulated on the ESW HDPE Return piping in Room 3101.

Ultimate Heat Sink Cooling Tower

Next the sections of ESW return piping located in the Ultimate Heat Sink Cooling Tower were evaluated against the proposed moderate energy crack criteria. For the seismic load case the term F_a is the OBE axial stress value, which can be found in calculation 2007-16601 Rev. 1 for member 42, node 105. Note that seismic anchor movements are considered negligible and are not included in the model per Section 3.1 of 2007-16601. Per 2007-16601 the A and B Train piping is symmetric and only the A Train piping is analyzed. The stresses calculated below will bound both trains and will be reviewed against moderate energy crack criteria.

$$F_a = 3133lb$$

The moment, M, is found by first calculating the individual moments, which are simply the OBE case values since SAM is negligible. The resultant moment is the SRSS of the individual moment values.

Individual Moment Values

$$M_X = 561ft \cdot lb$$
$$M_Y = 2235ft \cdot lb$$
$$M_Z = 4617ft \cdot lb$$

Resultant Moment Values

$$M = \sqrt{561^2 + 2235^2 + 4617^2} = 5160ft \cdot lb = 61921in \cdot lb$$

Next, the *Service Level B Longitudinal Stress* can be calculated using the same philosophy as that used for the A Train Return Line in Room 3101 of the Control Building.

A Train Return

$$0.5 \times \frac{45 \times 36}{2 \times 3.789} + 2 \times 0.5 \times \frac{3133}{383.42} + 1.0 \times \frac{61921}{2800.87} = 137.17psi$$

Note the minimum wall thickness is used as the nominal wall thickness to calculate the cross-sectional area and section modulus, which adds conservatism to the results.

In order to determine the *Alternative Thermal Expansion or Contraction Stress,* the resultant axial force due to range of thermal expansion (F_{aC}) and resultant bending moment due to range of thermal expansion (M_C) must be calculated.

For the thermal load case the term F_{aC} is the absolute sum of the axial thermal stress value of the hot and cold thermal cases, which can be found in 2007-16601 Rev. 1 for member 42, node 105. A Loss of Coolant Accident (LOCA) is not required to be postulated coincident with a pipe break. Therefore, the thermal case for LOCA will not be included. The stresses were calculated and reviewed against moderate energy crack criteria.

$$F_{aC} = 9727 + 4828 = 14555 lb$$

The moment, M_C, is found by first calculating the individual moments, which are the absolute sums of the hot and cold thermal case values. The resultant moment is the SRSS of the individual moment values.

Individual Moment Values

$$M_{CX} = 1710 + 822 = 2532 ft \cdot lb$$
$$M_{CY} = 9120 + 4777 = 13897 ft \cdot lb$$
$$M_{CZ} = 1061 + 586 = 1647 ft \cdot lb$$

Resultant Moment Values

$$M_C = \sqrt{2532^2 + 13897^2 + 1647^2} = 14221 ft \cdot lb = 170658 in \cdot lb$$

Next, the *Alternative Thermal Expansion or Contraction Stress* can be calculated for each train.

A and B Train Return

$$\frac{1.0 \times 170658}{2800.87} + \frac{14555}{383.42} = 98.89 psi$$

The *Service Level B Longitudinal Stress* must be added to the *Alternative Thermal Expansion or Contraction Stress.*

A and B Train Return

$$137.17 + 98.89 = 236.06 psi$$

The sum of the *Service Level B Longitudinal Stress* and *Alternative Thermal Expansion or Contraction Stress* is 236.06 psi for the ESW Return piping in the UHS Cooling Tower. This is less than the equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW return lines, which is 734.2 psi. Therefore, a moderate energy crack is not required to be postulated on the ESW HDPE Return piping in the UHS Cooling Tower.

6.0 IMPACT ASSESSMENT

This addendum for stress analysis calculation 2007-16760 was created to show that the above ground high density polyethylene (HDPE) piping in the ESW system located in Control Building Room 3101 and the UHS Cooling Tower is of sufficiently low stress, such that a break need not be postulated.

A search was performed in Director for documents linked to stress analysis calculation 2007-16760 and its addenda. Calculations EF-119, EF-120, 2007-18080, 2007-18081, 2007-18082, 2007-18083, 2007-16601, 2007-13241, 2007-11380, C-4166-00-2, 2008-12413, C-32-01-CP, C-32-01-F, S-22-01-CP, S-22-05-CP, and S-U-22-05-F were reviewed.

Calculations EF-119, EF-120, 2007-18080, 2007-18081, 2007-18082, 2007-18083, 2007-16601, 2007-13241, and 2007-11380 provide design inputs for this addendum. The outputs and conclusions of calculations EF-119, EF-120, 2007-18080, 2007-18081, 2007-18082, 2007-18083, 2007-16601, 2007-13241, and 2007-11380 are unaffected by this addendum.

Calculations C-4166-00-2, C-32-01-CP, C-32-01-F, S-22-01-CP, S-22-05-CP, and S-U-22-05-F perform analysis on the original buried piping that is no longer in service. These calculations are unaffected by the analysis performed in this addendum.

Calculation 2008-12413 performs that analysis for the piping in the ESW yard vault. This piping is located outside of the bounds of HDPE analyzed in this addendum. Calculation 2008-12413 is not a design input and is unaffected by the analysis in this addendum.

7.0 CONCLUSION

The sum of the *Service Level B Longitudinal Stress* and *Alternative Thermal Expansion or Contraction Stress* is 673.26 psi for the A Train ESW Supply piping and 717.48 psi for the B Train ESW Supply piping in Control Building Room 3101. This is less than the equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW supply lines, which is 773.6 psi. Therefore, a moderate energy crack is not required to be postulated on the ESW HDPE Supply piping in Room 3101.

The sum of the *Service Level B Longitudinal Stress* and *Alternative Thermal Expansion or Contraction Stress* is 300.58 psi for the A Train ESW Return piping and 441.04 psi for the B Train ESW Return piping in Control Building Room 3101. This is less than the equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW supply lines, which is 734.2 psi. Therefore, a moderate energy crack is not required to be postulated on the ESW HDPE Return piping in Room 3101.

The sum of the *Service Level B Longitudinal Stress* and *Alternative Thermal Expansion or Contraction Stress* is 236.06 psi for both the A and B Train ESW Return piping in the UHS

Cooling Tower. This is less than the equivalent moderate energy pipe break stress limit for the HDPE piping in the ESW supply lines, which is 734.2 psi. Therefore, a moderate energy crack is not required to be postulated on the ESW HDPE Return piping in the UHS Cooling Tower.

This addendum shows that the above ground high density polyethylene (HDPE) piping in the ESW system located in Control Building Room 3101 and the UHS Cooling Tower is of sufficiently low stress, such that a break need not be postulated.

There is no impact on operating margin. No changes to plant systems, structures, or components and their associated set-points that would affect plant operation have occurred in this addendum. The design margin for the A and B Train ESW Supply lines is 100.34 psi and 56.12 psi respectively. The design margin for the A and B Train EW Return lines in Room 3101 is 433.62 psi and 293.16 psi respectively. The design margin for both the A and B ESW Return lines in the UHS Cooling Tower is 498.16 psi.

The 10CFR50.59 impact is being evaluated in the licensing change package for CAR 201102957.

8.0 REFERENCES

EF-119 Rev. 0
EF-120 Rev. 0
2007-18080 Rev. 2
2007-18081 Rev. 1
2007-18082 Rev. 2
2007-18083 Rev. 1
2007-16601 Rev. 1
2007-13241 Rev. 2
2007-11380 Rev. 2
2007-16760 Rev. 2
NRC Branch Technical Position ASB 3-1
NRC Branch Technical Position MEB 3-1
Relief Request I3R-10
NRC SER I3R-10
ASME Section III Subsection ND-3600
ASME Code Case N-755-1
APA-ZZ-00662 App. F Rev. 5
CAR 201102957

9.0 ATTACHMENTS

N/A

LICENSING IMPACT REVIEW

(1) **ACTIVITY/DOCUMENT NUMBER** CAR 201102957, LDCN 13-0016

In answering the following questions, refer to ***APA-ZZ-00140 APPENDIX A***

(2) ***10CFR 50.59 Review***

(2.a) Perform **APA-ZZ-00143**, 10CFR50.59 Reviews, to determine applicability, screening, evaluation and approval authority per 10CFR50.59.

(2.b) Attach forms generated per (2.a) as appropriate. Indicate which forms are attached by the boxes below:

☒ CA2510 Applicability Determination (attached)
☒ CA2511 50.59 Screen (attached)
☒ CA2512 50.59 Evaluation (attached)

(3) **Technical Specification Bases Impact Review**

(3.a) Yes ☐ No ☒ Does the proposed modification/change/activity involve a change to the Technical Specification Bases?

If yes, include the bases change in the evaluation to be performed for the proposed modification/change/activity pursuant to **APA-ZZ-00143**, 10CFR50.59 Reviews, and process the bases change in accordance with **FDP-ZZ-00103. (T/S AC 5.5.14)**

(4) **FSAR Impact Review**

(4.a) Yes ☒ No ☐ Has an FSAR change been identified?

Does the proposed change, modification, or activity involve or require any of the following:

(4.b) Yes ☒ No ☐ A change (modification, addition or removal) to existing design bases, safety analyses or descriptions of existing structures, systems, components or functions described in the FSAR?

(4.c) Yes ☐ No ☒ Removal (from the plant) of any systems, structures or components described in the FSAR, or elimination of functions or procedures described in the FSAR?

(4.d) Yes ☒ No ☐ New design bases or safety analyses, or associated descriptions, that must be included in the FSAR?

(4.e) Yes ☒ No ☐ A new evaluation or analysis performed for Callaway, including an NRC Safety Evaluation Report (SER) or NRC-requested analysis, that makes existing design bases, safety analyses, or FSAR descriptions inaccurate or not bounding?

(4.f) Yes ☐ No ☒ A change to the organization (e.g., titles, reporting relationships, minimum qualifications) as described in the FSAR?

If the answer to any of the above is "Yes," ensure that a license document change request is initiated in accordance with **FDP-ZZ-00103** or contact Regulatory Affairs and Licensing to confirm that an FSAR change is required. If all of the above are answered "No," and a search of the FSAR identifies that no text or descriptive information needs to be changed, an FSAR change may not be required. Refer to FDP-ZZ-00103, License Document Change Process, or contact Regulatory Affairs and Licensing for additional guidance regarding what information or changes should be included in the FSAR.

Activity/Document Number CAR 201102957, LDCN 13-0016

(5) **COMMENTS**

List any special conditions or comments pertaining to these evaluations and certifications.

The proposed FSAR change will add text to describe the design bases for moderate energy pipe breaks in the high density polyethylene pipe (HDPE) material installed by MP 07-0066 and located on the 1974' Elevation of the Control Building. The new design bases for the HDPE piping are being submitted to the NRC for approval due to the conclusions in the 10CFR50.59 Evaluation, which is part of this change package. It is required to add the newly approved design bases to the FSAR to maintain the current level of detail.

(6) **APPROVALS**

Originator _Christine Norman_ Christine Norman 53587 Date 8/8/13

Qualified Reviewer __Tom Carr_ Thomas Carr 990 Date 8/8/13